Frequency counter/Oscillator stabilizer.

A universal oscillator stabilizer based on PA2OHH's binary LED frequency counter.

On1mws.

In one of our emails, my friend Frank.W.Harris, wrote to me about his efforts to build a discrete frequency counter. A counter without a PIC/microprocessor but with 1970s logic ICs. We both are not great fans of modern digital circuits. To help out, I send Frank a schematic of an 'all 1970s logic ICs' frequency counter out one of my books. It is an elaborate circuit.

In hindsight, my utmost homebrew fun was always finding ways to stabilize analog oscillators. The 2010 PLL and especially the 'easy' PLL for my CW rig were satisfying builds. Figuring out how to build an all HF band H&P stabilized oscillator for the SSB rig was also exciting. After seeing the schematic that I just send to Frank, I realized that the frequency readout of the lowest 7 segment display could be used to stabilize an oscillator. A short search on the net learns me that is (obviously) already been done. But uniquely with microprocessors. Not with standard logic ICs.

Why would you? In my opinion there is no homebrew fun in PICs. It is just a black box for me and would have to spend countless time to learn how to program them. "If you love tax accounting you'll love digital" must be Frank's funniest quote.

A quick look at the schematic of the 'all logic-ICs' frequency counter learned me that stabilizer would be a 'bulky' circuit. First I would need to try to simplify the circuit to one 10Hz display. Secondly construct a logic circuit to convert the 7 segment display information to an analog VFO control voltage. A huge task/large circuit.

A couple of days later it struck me, I have already build a 'logic IC' frequency counter. Many years ago, in 2008 in fact. It is simple, works well and use it every time my CW rig is turned on. It is my oldest HF circuit still in use. PA2OHH"s SUSI frequency counter.

I'm out of homebrew project ideas, anno 2023. So why not attempt a 'regular logic ICs' frequency loop oscillator stabilizer?

1) Pa2ohh's 'SUSI' frequency counter.

Instead of the normal readout with digits, the SUSI frequency counter gives you a binary LED readout. How does this work if there is no digit display? For the pictures below I tuned the frequency of my CW rig up an took a picture every time a bit changes.

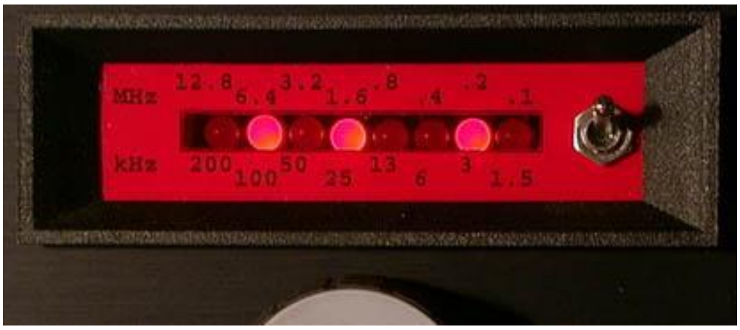
11000001 11000010

11000011 11000100

Decimal number	Binary number
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

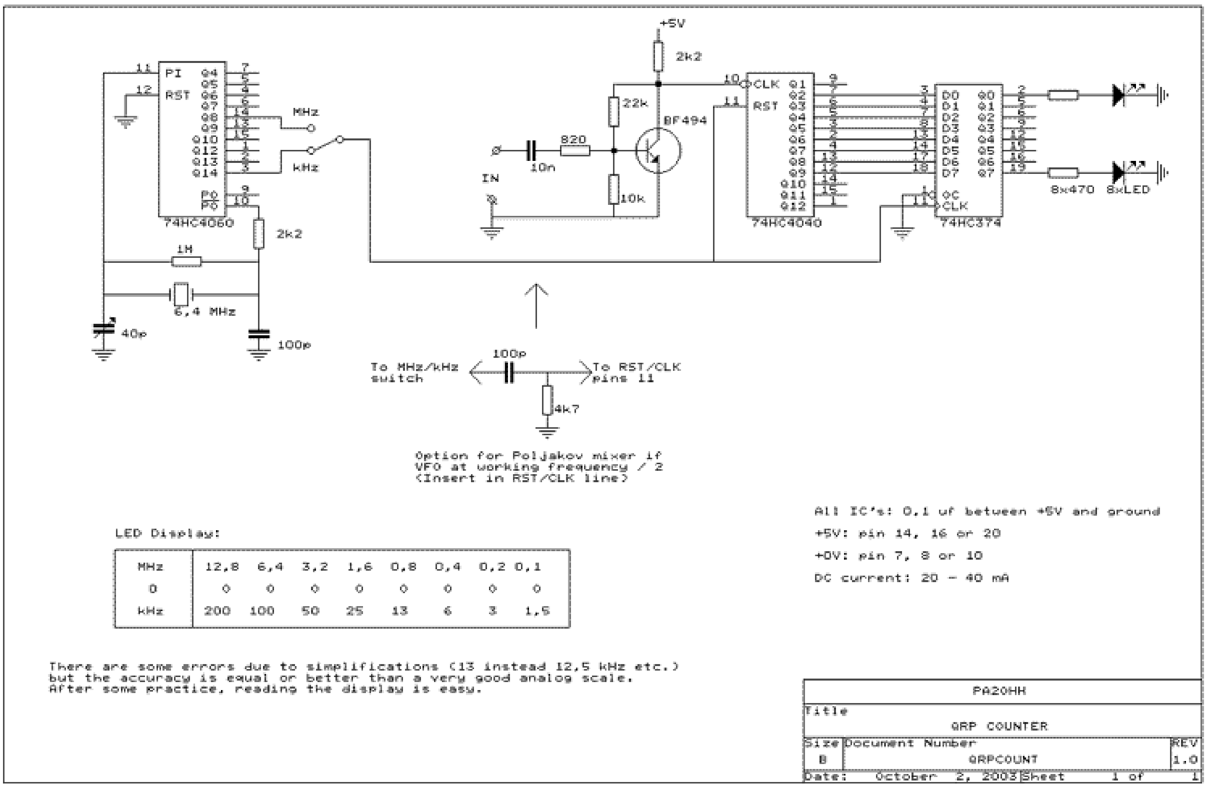
Clearly the display counts up in a binary way. The circuit is not a real frequency counter but a ‘drift’ detector. In the above case the oscillator is tuned 4 bit up. 4 X 1,5Khz = 6Khz. The counter does not tell you What the actual frequency is.

However, the circuit could be used to actual measure the frequency. On Pa2ohh’s Website, Onno demonstrates how you can combine the Mhz and Khz readout to calculate the actual measured frequency.



For myself, I use the circuit in a different way in my CW rig. I never bother to calculate the frequency. I know which LEDs need to be lid up for interesting frequencies like 7030KHz. Or if I hear an interesting signal I memorize which LEDs are lit up, or take a note, to eventually find it back later on. For my three narrow band CW transceiver the system is perfect and avoids all modern PIC and DDS stuff. Pa2ohh's SUSI circuit seamlessly fits a simple homebrew rig.

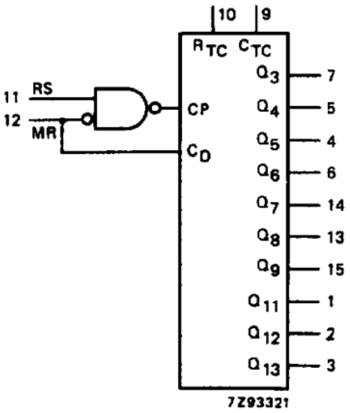
The copy I made in 2008 worked immediately. How it exactly worked was not clear to me. Actually, I never bothered to figure it out because instantly working circuits do not stimulate you to do so. Now, 15 years later I realized it might be a good idea to try to understand Pa2ohh's circuit.

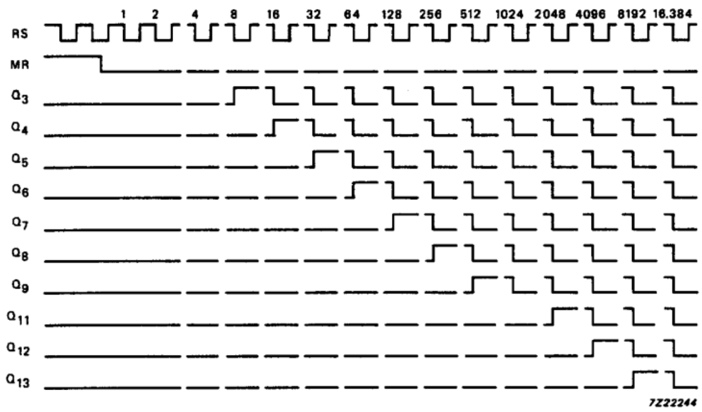


Above, the original PA2OHH 'SUSI' frequency counter circuit.

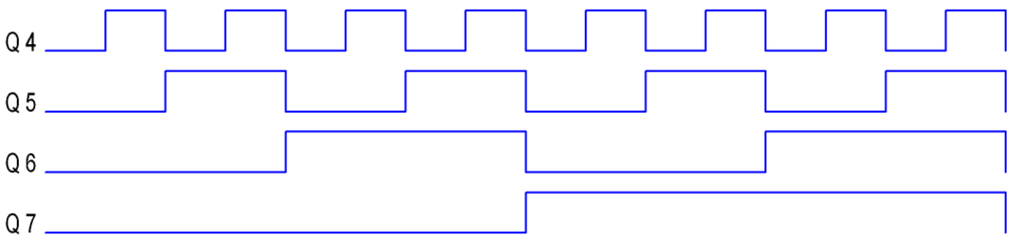
Basically there are 3 circuits, A 74HC4060 clock oscillator, a 74HC4040 divider and an IC I have never seen, a 74HC374.

As a reference to measure the oscillator drift, a HC4060 is used to generate a clock pulse. A HC4060 is a binary ripple counter with built-in oscillator.





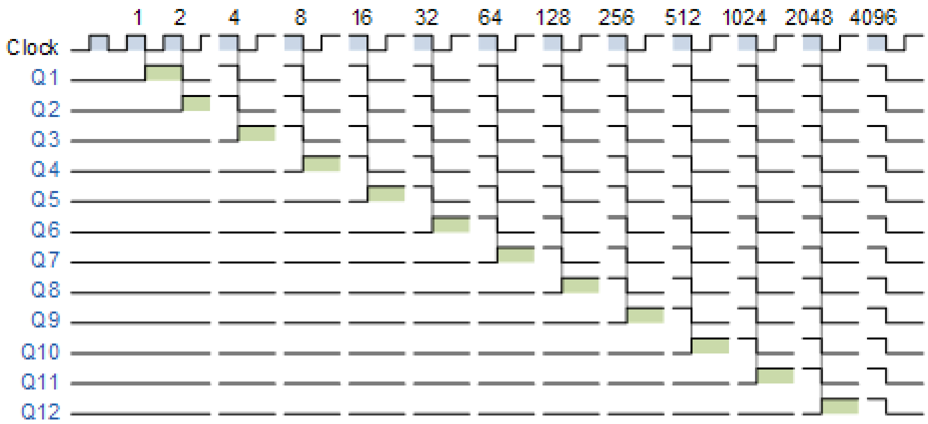
Above the circuit and timetable from the datasheet. The timetable is not easy to interpret because the RS input is displayed with bit jumps to save horizontal space on the datasheet.



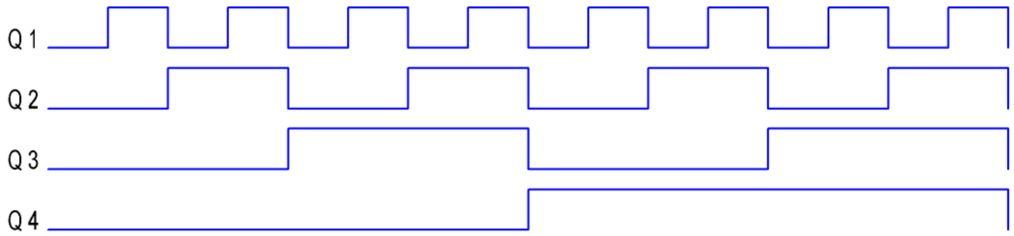
Here a timetable of the first four outputs, drawed without bit jumps.

The IC features 10 divisions of the crystal frequency. The first output is not the first division but the 4^{th}. Output pin 7 is therefore crystal frequency/16 (4X4=16) Every folowing output divides the crystal oscillator frequency further by two.

The oscillator input is divided by a HC4040. This is a 12 stage binary ripple counter. Basicly the same as the 4060 but without the internal oscillator.

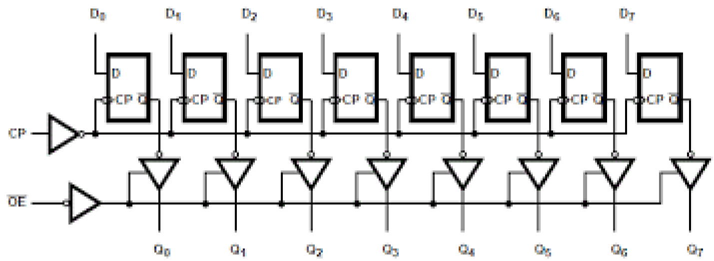


On every output of the IC the frequency is half that of the preceding output. Again the clock pulse is displayed with bit jumps, on the datasheet, to fit the datasheet page.



So this is a realtime drawing of just 4 outputs. Every output is half the frequency of the preseding output.

Our last IC is a 74HC374 which contained 8 separate flip flops. Flip flops can be used as data memory storage.

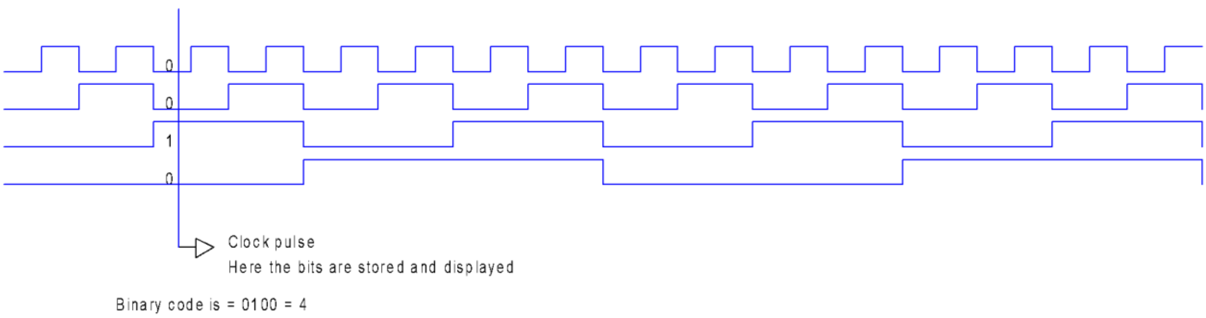


How these circuits interact is not immediately clear, at least, not to me.

The below text is taken straight from Pa2ohh's webpage.

Working principle
The 74HC4060 oscillator with the 6.4 MHz X-tal generates a frequency of 390.625Hz in the kHz position of the switch and 25 kHz in the MHz position. Only half the period is used for counting. During the +5V half period, the 74HC4040 is reset. As soon as the clock pulse goes to zero, the 74HC4040 starts counting the pulses from the BF494 preamplifier until the clock pulse rises again to +5V. Then it is reset again. But just before the reset, the actual count value is latched in the 74HC374, that also drives the output leds.
And that is all...

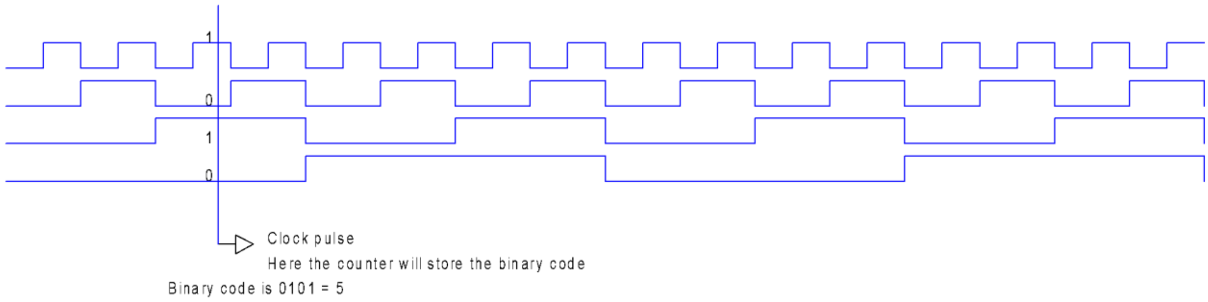
Okay, so on every clock pulse, the 'count value' is stored is the 74HC374 and binary displayed on LEDs. It is still not fully clear to me how this works so I tried drawing timing diagrams. The square waves are the divided oscillator signals on the 74HC4040 outputs.



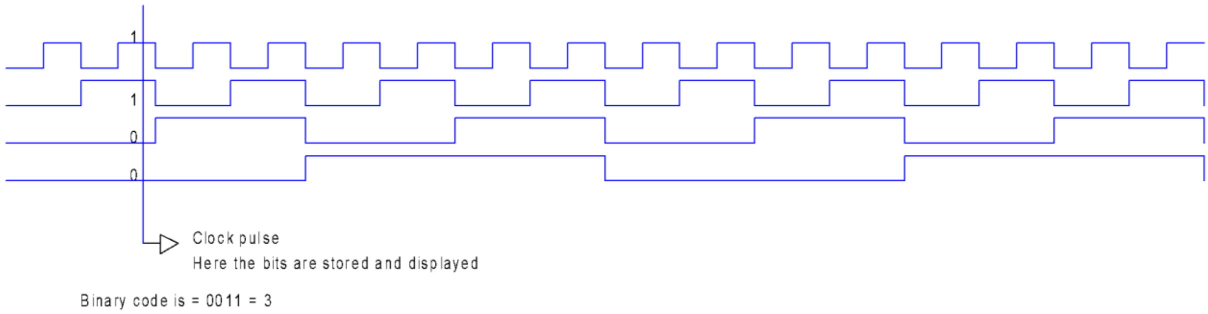
In the above example a 0100 binary code will be displayed on the LED's.

What will happen when the oscillator frequency drifts up? The period of the oscillator signal will decrease but the period of the clock pulse stays the same.

Because ‘TinyCad’ does not allow me to draw fine enough, I drew the clock pulse a little more to the right. I increased the period of the clock signal in the drawing, which has the same outcome as a decreased oscillator frequency.



Now the binary readout is 0101 instead of 0100. The Kiss frequency counter has displayed a 1 bit increase, telling you that the oscillator has drifted up.



If the oscillator drifts down the period of the oscillator signal increases (drew as a decreased clock signal) and a lower binary code is displayed.

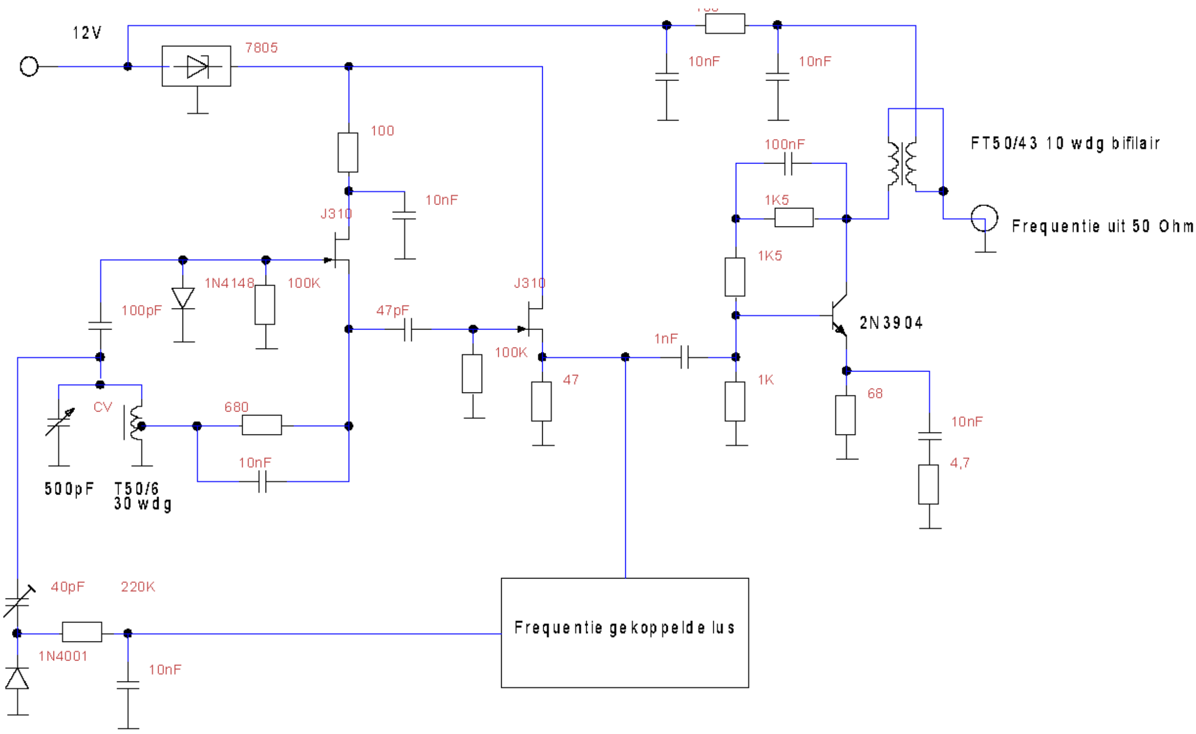
The binary readout resolution is always the same. Whatever the input frequency is. 2, 5 or 18Mhz, it simply does not matter. So in Pa2ohh’s circuit the resolution in the Khz setting is 1,5Khz. The period of 1,5Khz is 0,666mS (F=1/T) A 1,5Khz frequency drift will always be the same 0,666mS decrease or increase no matter what the frequency input of the oscillator is.

A higher clock frequency leads to a lower resolution for the readout and vice versa. This remains entirely blurred to me. Nevertheless, now I have some idea how Pa2ohh’s circuit perhaps works.

It is noticeably a very cleaver circuit. Stunning in its simplicity, innovative and effective at the same time.

2) Getting started.

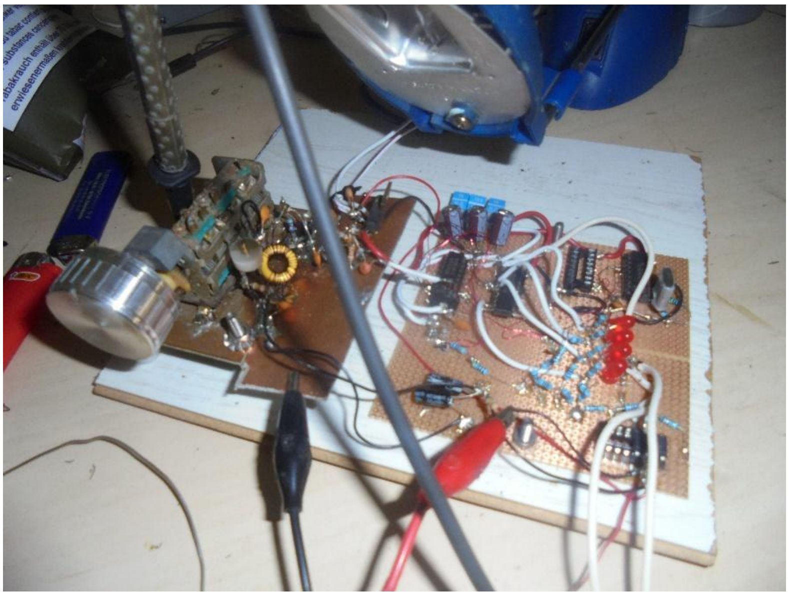
Below, the victim oscillator.



Oscilator

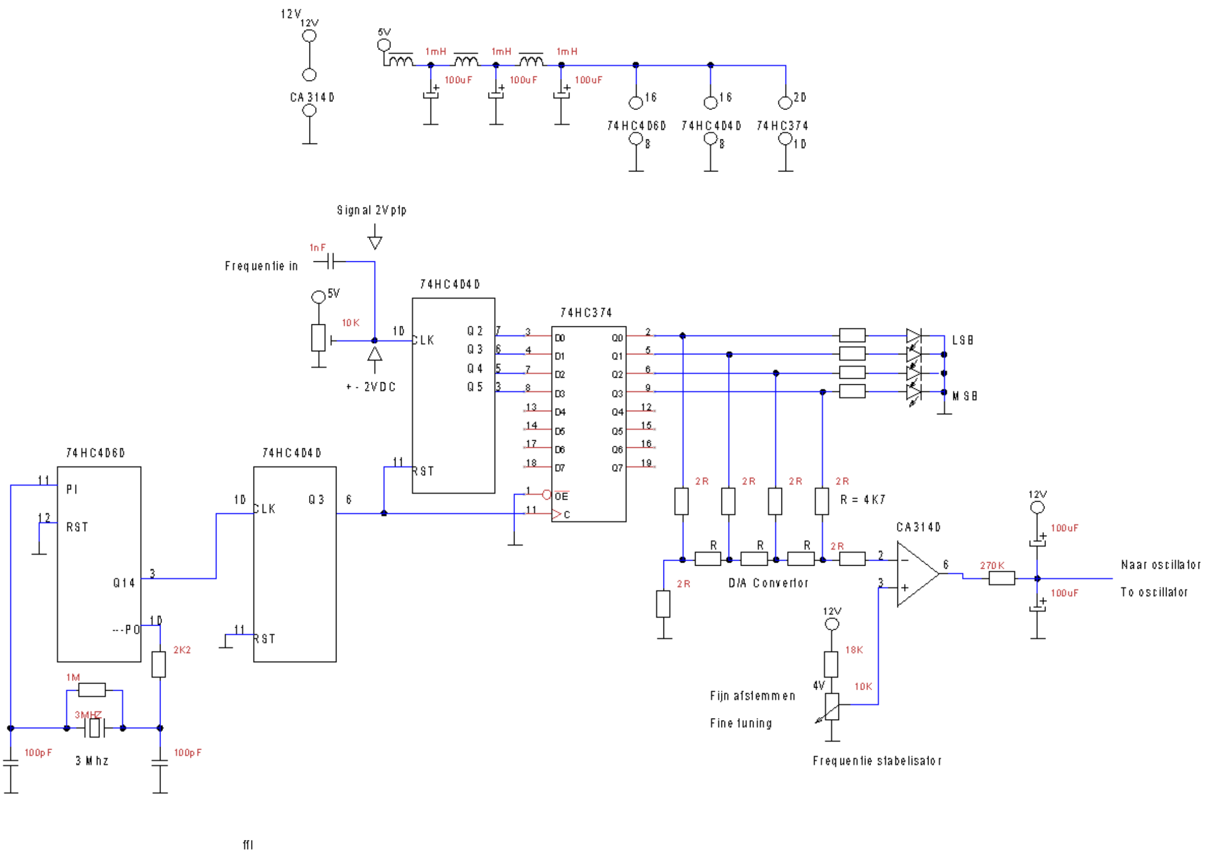
Exclusively for the test I build (my usual) Hartley circuit with J310s. However, these days, I settle for 50 Ohm buffer amplifiers. The last buffer amplifiers is powerful enough to drive a diode mixer. The oscillator above tunes from about 6 to 18Mhz. It drifts as expected a lot, especially as it is not canned at all. If you would use it as it is in a receiver, you'll be busy retuning all the time… Unusable in a transmitter.

An ordinary 1N4001 diode serves as varactor for the stabilizer correction voltage.



The prototype looks horrifying by the way.

Below the first stabilizer prototype.



The circuit obviously begins with Pa2ohh’s frequency counter. To simplify and minimize components, my version only use 4 bits instead of the 8 bits from the original frequency counter.

Clock frequency is 48,8Hz. To reach such a low clock the signal of the 4060 had to be divided further by a 74HC4040 IC.

To convert the binary readout into an analog voltage, the 4 bit are fed into a simple resistor digital/analog convertor. The voltage will vary between 0 and 4 Volt.

This voltage is fed to a opamp comparator. An inverting comparator! If the frequency drifts up, the voltage after the D/A convertor will also go up. If the voltage rises above a preset voltage, the comparator will sink the voltage over the integrator and thus lower the oscillator frequency.

The preset voltage of the comparator can be set with a potentiometer and acts effectively a fine-tuning of the oscillator. If the correction loop is working correctly, the stabilizer can be locked on any of the binary values of the frequency counter with the fine-tuning. The opamp is a ‘reel to reel’ CA3140, which is a cheap common opamp.

Vice versa, if the frequency drift down, the voltage after the D/A convertor drops below our pre-set value and the comparator increases the voltage over the integrator. Consequently, the frequency goes back up again. This is why the comparator must be inverting.

The correction pulses of the comparator are fed into a simple integrator to insure a smooth loop. Without an integrator, the oscillator would go nuts.

The LEDs could be omitted but with the LEDs you can actually see the stabilizer lock.

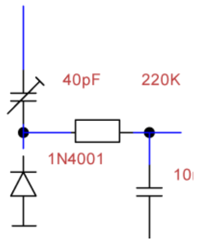
3) **Plug and pray.**

So that's the theory, How does it turn out in practice? The first prototypes locked extraordinary easy.. within 10 minutes I got a rock solid lock ·. First conclusions…

The finetuning (4 bits) has 1,2khz band spread, locks (1 bit) are less than 100hz apart, more than adequate to listen to CW and SSB.

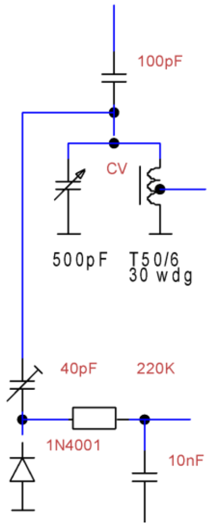
It is impossible to lock in between lock points, so a higher clock frequency leads to unusable spaced lock points.

To have a good lock the trimmer-C, which determine how much influence the stabilizer has over the oscillator, must be set properly.



Too little (less coupling) and the lock gets very slow and the entire 4 bits can't be tuned. Too much coupling and the oscillator goes berserk. Finding the right setting is relatively easy.

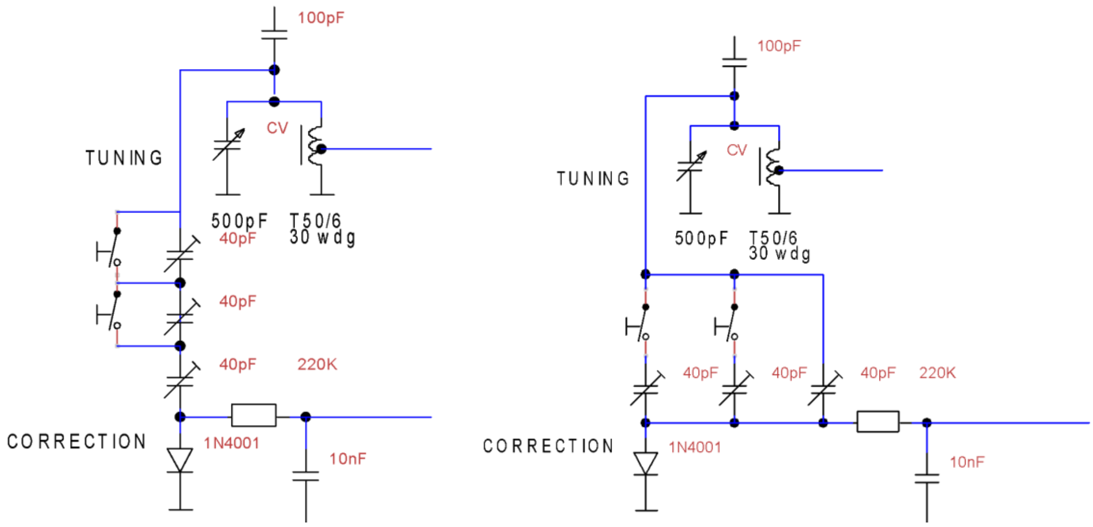
However, there is a complication for wide band oscillators…



If the oscillator is tuned to the lowest frequency, the capacitor will be large, say 450pF. I have no idea what the capacitance of a 1N4001 is but let's assume it's about 35pF. The ratio of the tuning and correction capacitance is 450/35= 12/1. If the oscillator is tuned to the highest frequency, the capacitor will be small, say 75pF. The capacitance of a 1N4001 remains about 35pF. The ratio of the tuning and correction capacitance is now 100/35= 2,8/1. This means that the frequency correction, caused by the stabilizer will be a lot larger when the oscillator is tuned to a high frequency. Thus one setting off the correction capacitor will not work for a wide-band oscillator. The same problem you run into if you would like to build a multi band H&P stabilizer.

With the above oscillator I suspect you'll need 3 settings. In a 4 a 5 MHz wide oscillator one setting should do.

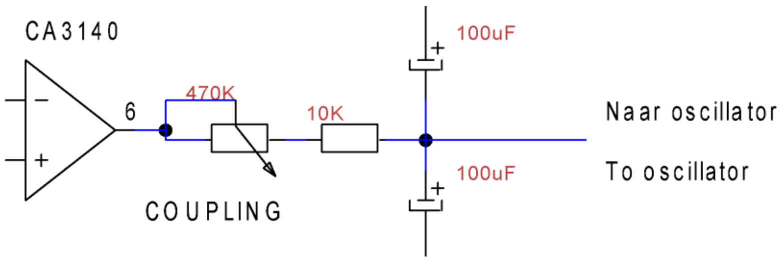
Solutions for a wide band oscillator…



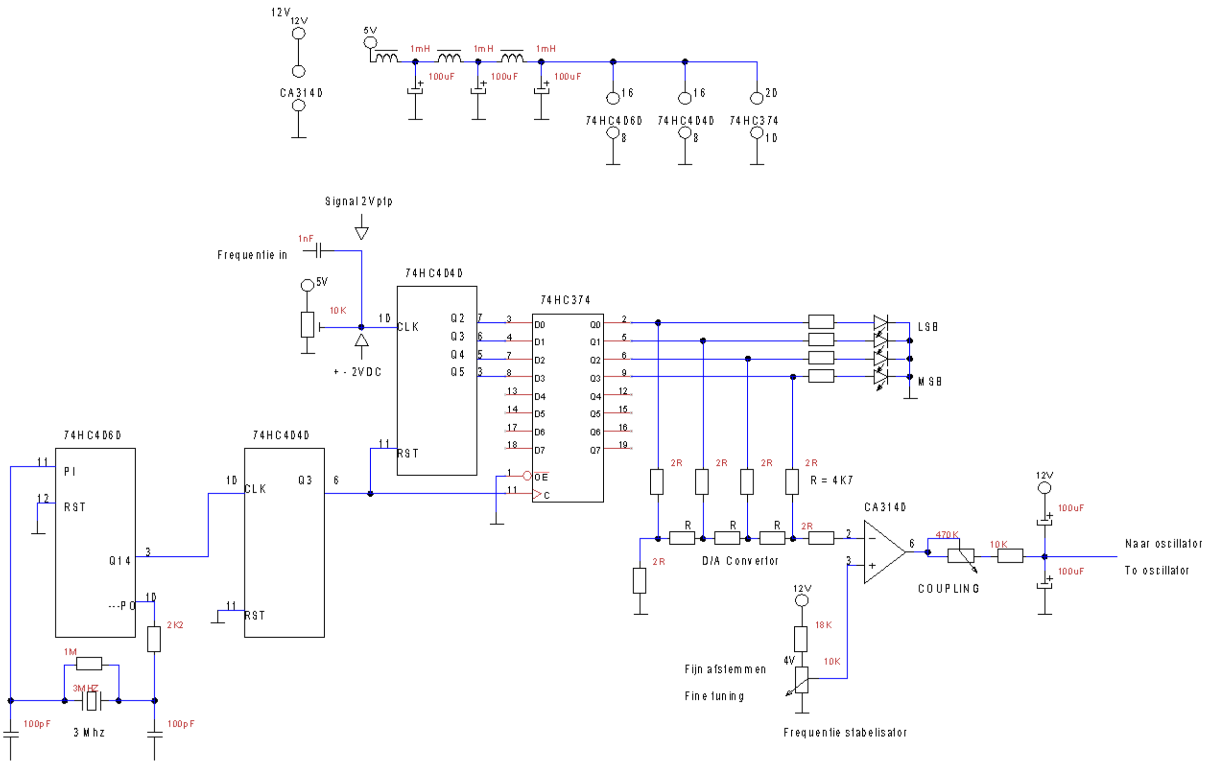
(the 1N4001 diode is accidentely drawn upside down)

One way could be to have switchable coupling. Though, the above scematics will only work if your switches are close to the oscilator circuit and schielded for hand effect. Relays could be used instead of switches, but that takes space and is expensive. For all clarity, I did **not try** the two above circuits.

Another observation is that slowing down the integrator results in a the need for more coupling between oscillator and stabilizer, and vice versa. Brings us to another way of varying the coupling if we want a wide-range oscillator stabilizer.



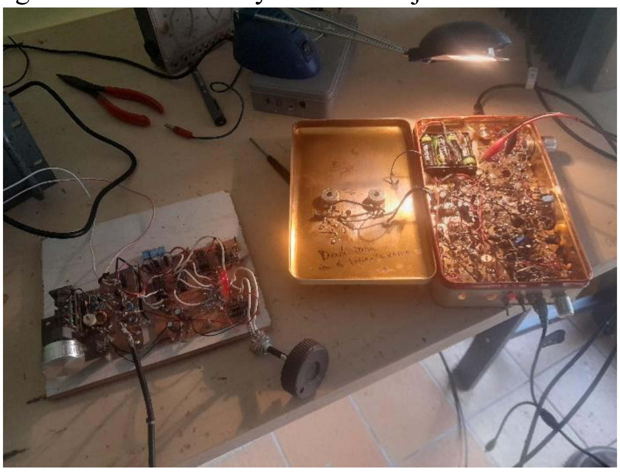
The potentiometer is set to maximum resistance if the oscillator frequency is maximum and set to minimum if the oscillator frequency is minimum. A front panel potentiometer is a lot more practical than a bunch of switches close to the oscillator. Practical and easy sounds always inviting to me so I used that idea instead.



Above, the second prototype, capable of stabilizing the wide-range 6/18 MHz oscillator on page 8.

Bad points for the stabilizer,

- The frequency counter never makes his mind up and the ‘least significant bit’ is nearly always ‘blinking’. This causes a very short term ‘jitter’ around the center oscillator frequency.



When I connect the test oscillator to the digital frequency counter of my SSB rig I can’t see the last digit interchange. Rock solid. However, the lowest digit is 100Hz.. I do not own a commercial frequency counter with a lower resolution. To figure out how dramatic this jitter could be, I connected the test oscillator to the mixer of my ‘Holliday’ radio. For a couple of weeks in April ’23, I listened to the 40M band.

Can I hear the jitter in the CW and SSB signals..? Well, no, not at all. Everything sounds faultless. The integrator filters out the jitter. The weeks I tried out this setup led me also to enjoy the strong points of the stabilizer.

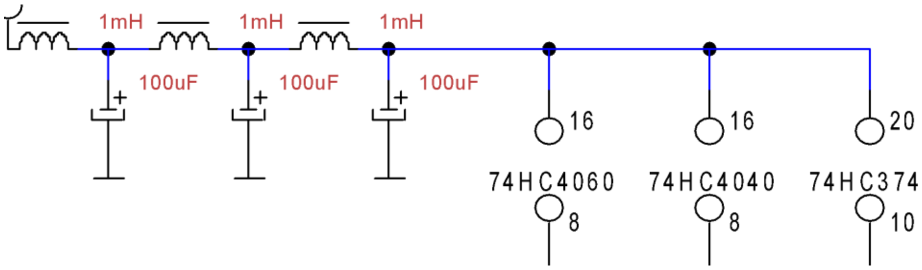
Strong points,

- The lock is very robust, almost PLL like. Superior to H&P stabilizers. The circuit can handle some physical shocks.
- The circuit has **two lock points**. In the above example, the first are about 75Hz apart (1bit) These 75Hz lock points are pretty much rock solid. The second lock points are 1,2Khz apart (4bit, fine tuning). To make the circuit jump to the next 1,2Khz ‘window’ a physical shock is necessary. The circuit is however more immune for this than H&P circuits (which can even be made to jump to the next lock point by a coffee mug being put on the table)
- The resolution, lock points distance is always the same whatever the input oscillator frequency is… Unlike a H&P circuit which needs different oscillator divisions (extra circuitry/switches) to have equal lock points spacing over a wide range of input frequencies.
- The integration time for a stable frequency lock loop seem to be much less critical than a H&P circuit. Marrying your oscillator and stabilizer is easier.
- A simple H&P stabilizer that tames a wide range oscillator isn’t going to happen, unless you build a complicated circuit like in my SSB transceiver. However this stabilizer can do that job relatively simple.
- Easier to understand how it works compared to a H&P circuit = easier to build and troubleshoot.
- It locs and keeps locking!

4) Building it.

- Get yourself a working oscillator. Hartley designs, with a centertapped coil, nearly always work on when first turned on.
- Build the SUSI frequency counter. Preferably test it with a signal generator to be sure there is a correct binary readout.
- Add the D/A convertor. Test that the voltage follows the binary readout.
- Add the opamp comparator. The output voltage should swing from 0 to supply voltage as you turn the potentiometer.
- Connect the integrator to the oscillator and find the right integration time. The higher the frequency, the slower it must be.
- More coupling between the stabilizer and oscillator needs a slower integrator and vice versa.
- All things considered, it’s a lot easier than a H&P stabilizer.

5) A must!



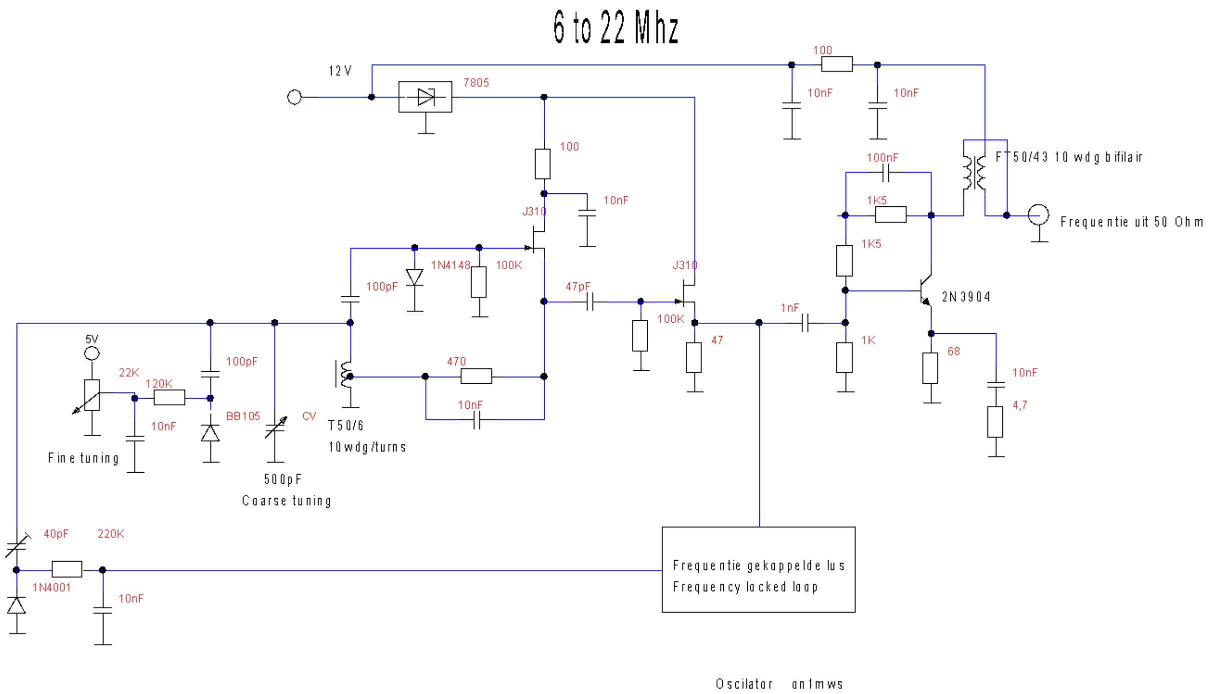
The L/C filters are essential. Without this filter you will hear the LED's turn of and on in your receiver. There is a voltage drop caused by the filter so they can also be put in front of a 7805V regulator. My SSB rig has 2 L/C filter before the 7805V regulator and 2 L/C filters after. 4 in total. A bit of overkill does not hurt in this case.

6) Unforeseen work.

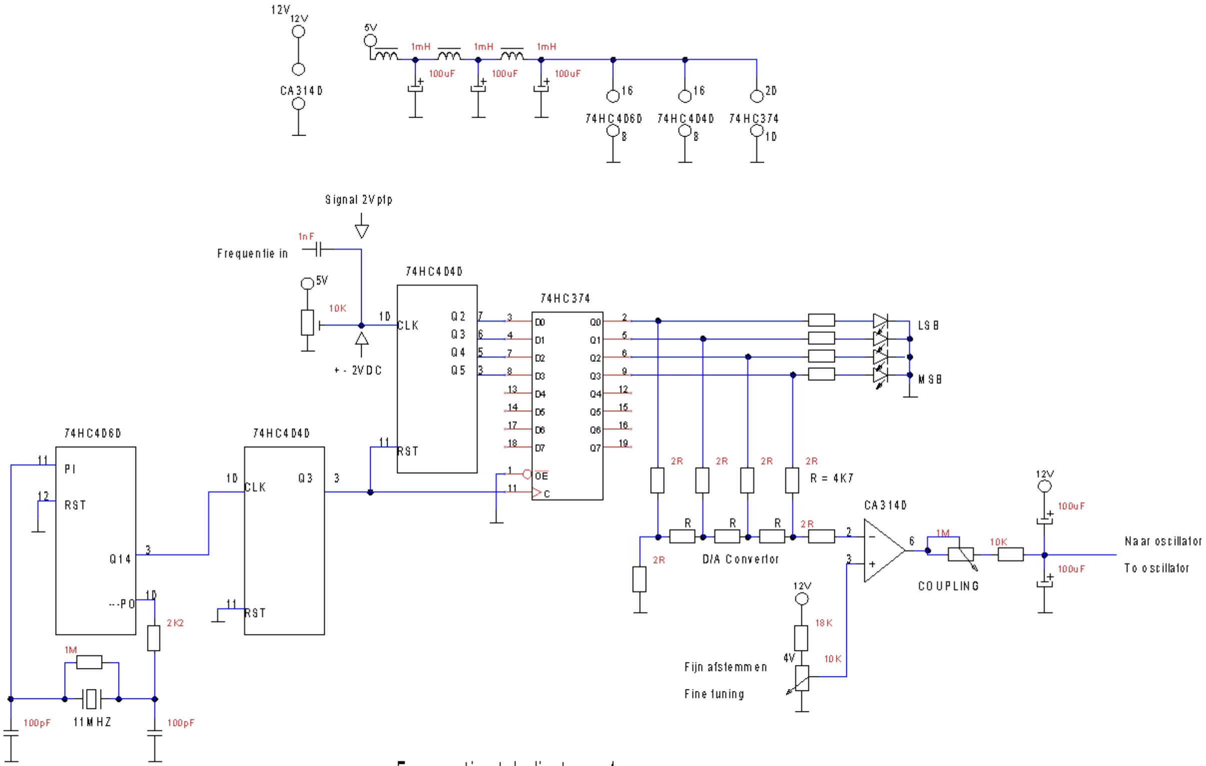
At the start I just wanted to see if I could construct a 1970s ICs frequency locked loop. I was not planning to do anything with it. Because, since 2008, when I started listening to the short wave bands a lot has changed. Only two MW stations left… No more BBC world service…No more world broadcasters… only the lower Ham bands remain active. When I listen in most of these guys are well into retirement. Soon the Ham bands will be quiet to , I guess… My kids don't even have interest in a normal FM radio.

Nevertheless, the circuit works so well, and probably better than a H&P it feels a shame to nothing with it and decided to scrap my 40M band 'Holiday' radio and rebuild it into a multi band radio.

And above the end result. All the RF radio circuits are ‘upstairs’ and the oscillator and stabilizer ‘downstairs’. In my junk I had a beautiful 500pF air variable tuning capacitor.



The final oscillator tunes from 6 to 22Mhz so 5 bands can be received. 160,80,40,30 and 20M. Only thing new is an extra ‘fine tuning’.



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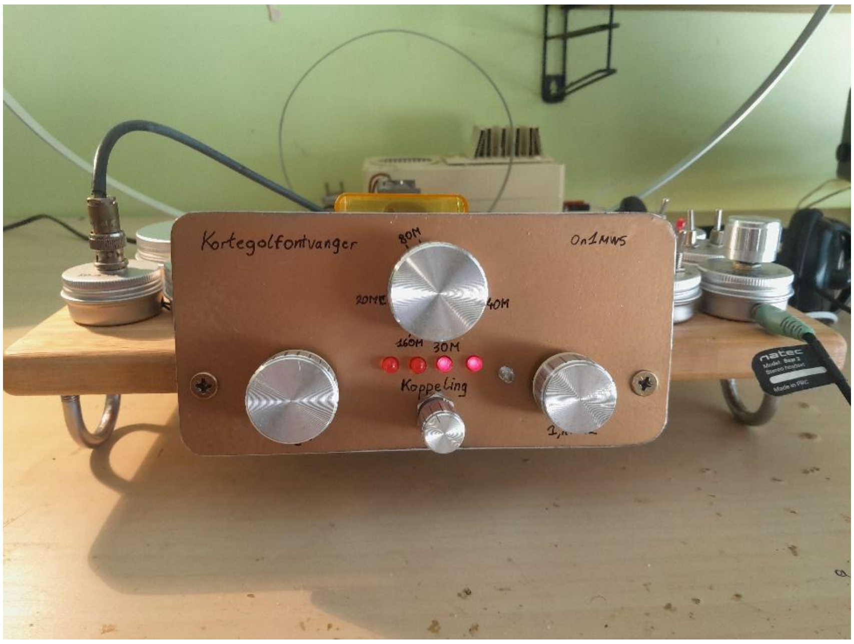
And above the final stabilizer. My 3Mhz crystal did not survive the re-build so an 11Mhz crystal is used with more division on the 4040. Lock points are less than 100Hz apart and the overall 16-bit tuning about 1,1Khz. Because the final oscillator works a little higher than expected I needed less coupling so the 470K pot is replaced with a 1M pot.

The oscillator has his own can but the stabilizer had to be divided over two cans.

The oscillator stability is amazing. It simply locks and keeps on locking. Leisurely listening without ever the need to retune



Oscillator front panel

7) Left to do…

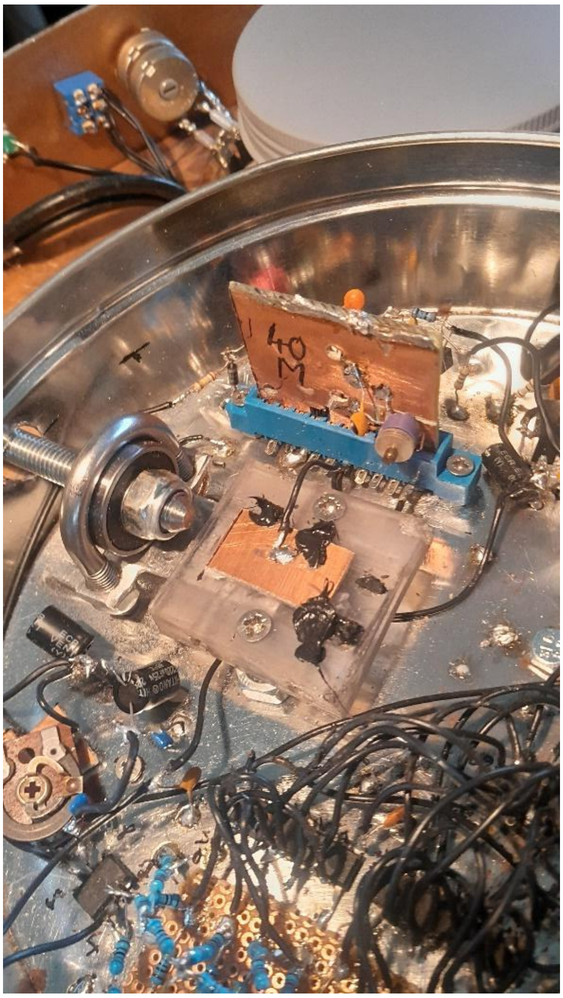
What I did not do is work out the mathematical relationship between the clock frequency and lock point space. I will probably never bother. Also I have no equipment or knowledge to properly test the oscillator on how 'clean' it is. Also left to do is connect the oscillator to one of my transceivers to check out if it is good enough for a transmitter.

But would I prefer this stabilizer over an H&P stabilizer for a receiver? Any day of the week.

8) Even more unforeseen work.

Instead of connecting the stabilizer to one of my transceiver to figure out if its good enough for a more challenging task, I figured I was totally bored with my 2014 homebrew CW transceiver and decided to completely scrap it. Use some new HF circuitry, but especially get rid of the modern PLL and use the LED counter/stabilizer.

Instead of rebuilding a wide range oscillator, I opted for narrow band operation. And build my very first homebrew tuning capacitor. To change bands several small PCBs are made. Every band has about 100KHZ tuning range. My homebrew capacitor has a 20/1 gear reduction, so that's convenient.



Oscillator and stabilizer are fitted inside an old tin can. A ‘Quality street’ candy box. If you can, find a Belgian chocolate box. Much more tasteful. Above, the homebrew capacitor and insert band PCB.

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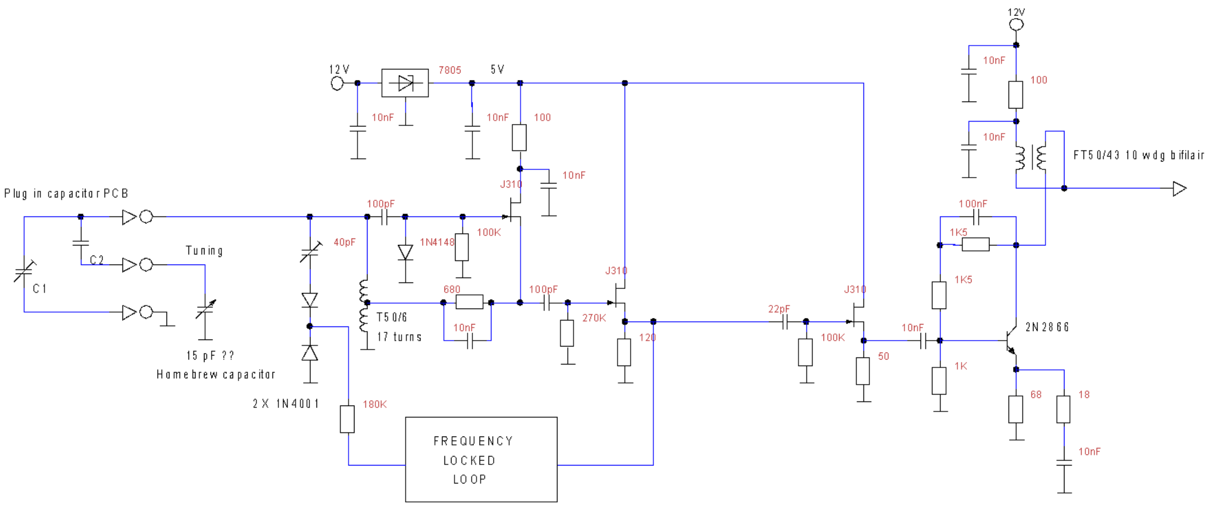
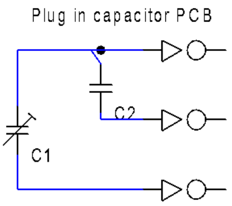
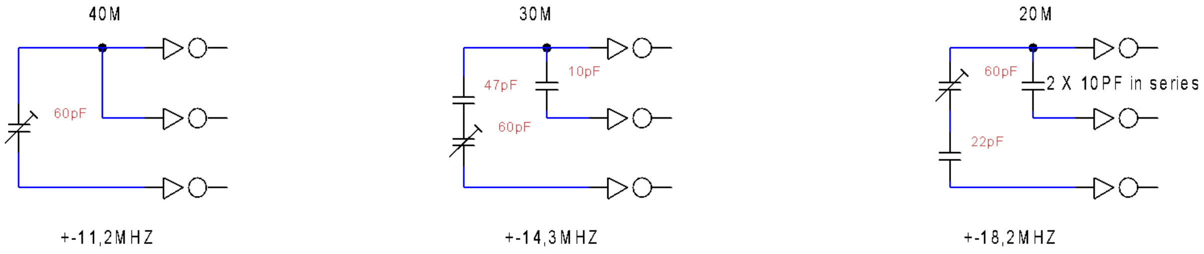
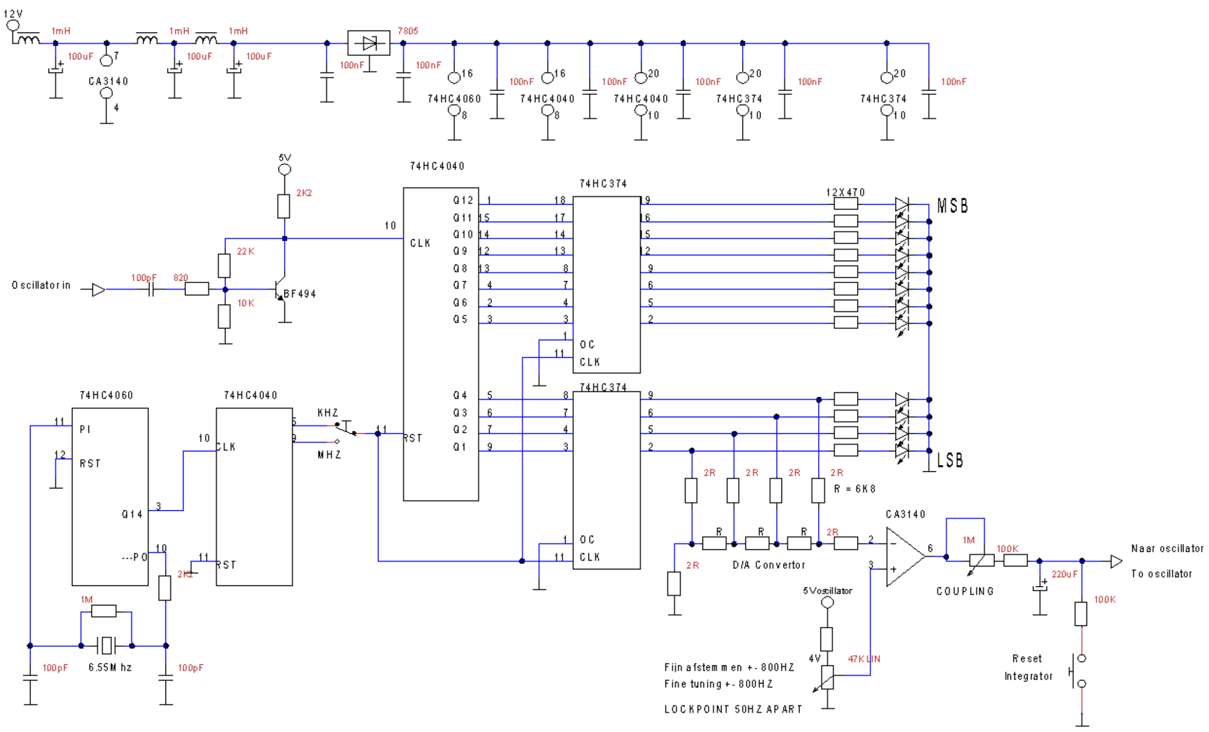


The output on the 2N3866 amplifier is enough for a diode ring mixer. I measured 1,4Vptp on the input of the mixer. Notice the extra J310 buffer amplifier.





PA2OHH’s counter features 8bits, my holiday radio, 4bits. For the CW transceiver I wanted combine both, a complete frequency readout but with a low enough resolution for the couple loop. So I build a 12bit version of PA2OHH’s circuit. The circuit below has a resolution of 50HZ. My first idea was to build two readouts. An 8bit frequency counter and a lower 4 bit counter to be used for the couple loop. However, turns out that the 374’s must be fed from the same 4040 if you want a consistent flow between the LEDs.



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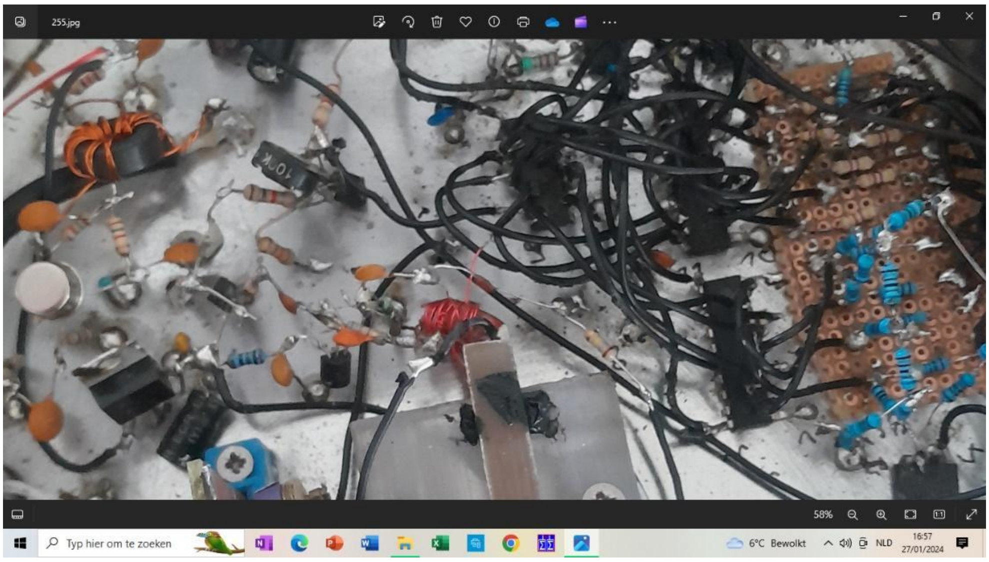
The stabilizer worked immediately. Lock points are 50Hz away and the finetuning range is about 800HZ. You could use more bits to lock the oscillator, but I believe 4 bit is perfect.

There is a MHZ readout. So I can check I'm on the right frequency after I swapped oscillator band PCBs. Just an extra convenience. But to use the FLL, the circuit must be set on KHZ.

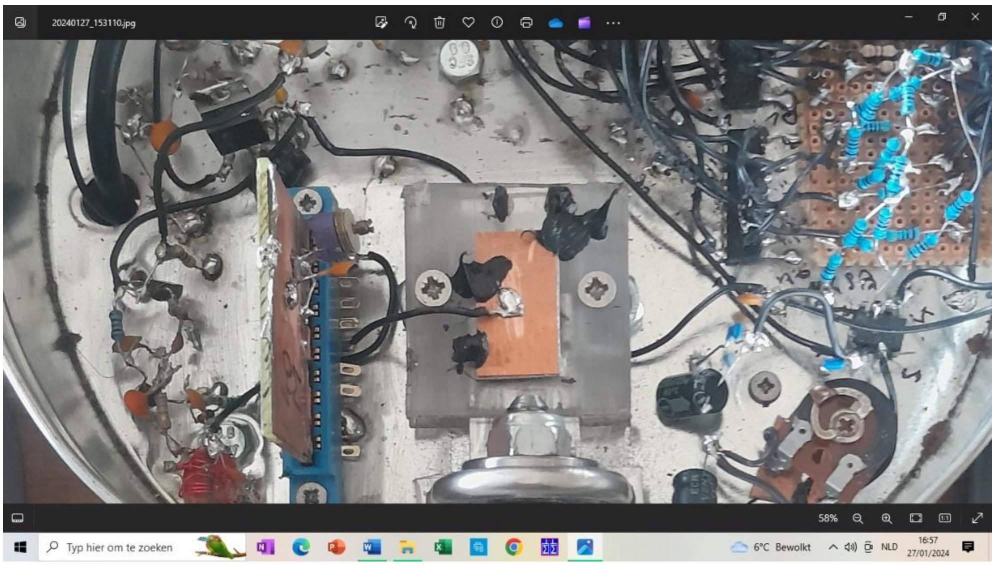
9) 25mm is enough.

I only encountered several problems before I got a reliable SUSI locked loop. .

The clock frequency was leaking in the oscillator. Both the oscillator and stabilizer were built in one enclosure. I expected that such a low frequency could not radiate, but I was clearly mistaken.



Above the first version. The oscillator was only a couple of mm away of the digital circuits. When receiving a signal this was clearly audible.



This the final version. The oscillator is now located to the left and the capacitor is made smaller to gain distance from the digital circuits. The distance from capacitor to digital is about 25mm. This is enough to stop the radiation. I also experimented with a small aluminum screen. This also stopped the radiation.

Second problem was a problem very few Hams are aware of. When you switch from T/R or R/T, the oscillator gets a push which might get it of frequency. Any set with a modern DDS or PLL will be so good that is not a problem. But a homebrew set with a free running oscillator might get into trouble.

This problem becomes worse as the frequency goes up. The original version had the buffer amplifiers like one page 14. The T/R jump was okay on 40M, problematic on 30M and making 20M unusable. After a T/R the stabilizer needed seconds to get back on frequency. On 30M the jump could cause the stabilizer to the next 800HZ window, on 20M the jump became too much.

Eventually I used 2 J310 buffer amplifiers after the oscillator instead of 1. The J310 amplifiers do not amplify, they just isolate the oscillator from the naughty mixer. After this modification the oscillator turned out to be completely immune for operating the T/R switch. The buffer amplifiers on page 14 are more than okay for a receiver but for a transceiver you need the buffer amplifiers on page 18.

Another problem was an erratic lock while operating on 30M. Sometimes the lock was okay, later on to fast or the oscillator went mental. Took me a while to realize that that I, by accident, made the 30M oscillator PCB out of double sided PCB. The backside was not connected to ground and was floating… After connecting this side to ground all erratic behavior disappeared.

All these problems let me enjoy one of the advantages over a H&P stabilizer. Much easier to troubleshoot!

10) A glitch that very nearly drove me insane.

The symptom of the glitch was as follows. Usually the SUSI stabilizer locked after a couple of seconds after the rig was turned on. And kept on working flawlessly from then on. But sometimes the SUSI stabilizer did not lock after turning the rig on. I could see the oscillator drifting down slowly. Sometimes after turn-on, the SUSI stabilizer did lock but way too slow. setting the lock to a lower bit number was never a problem but setting the lock to a higher bit number took way too long. Seemed like the integration time was not stable. As the SUSI stabilizer for the holiday radio has never shown this glitch it took me a while to figure this out.

Naturally I suspected faulty components and intermittent contacts. Took me a long time to understand the real cause. It turns out that the maximum voltage on the integrator capacitor is about 9 Volts. The frequency locked loop can no longer steer the oscillator up after the integrator voltage has reached this voltage. I assumed that the maximum voltage would be close to 11V but turns out to be much less. Amazingly enough this errant problem always starts after a turn on of the rig.

As a solution I mounted a push button that connects a 100K resistor to ground to lower the integrator voltage. If I notice the problem after I turn on the rig, I simply push the button a couple of times. About 4 seconds is usually enough.

As a best practice I now turn the tuning capacitor in maximum capacitance and switch the frequency counter to MHZ. I have written down the binary LED outputs I should see for every band.

If the integrator voltage has run by accident to its maximum, the oscillator frequency is slightly higher. About 15KHZ. So I switch to MHZ and push the button until the MHZ readout is spot on and switch back to KHZ. After this the integrator voltage has dropped and the SUSI stabilizer works impeccably.

From them on the rig can be used for hours on end. Usually the integrator voltage settles between 4 and 6V.

10-continued) Insight comes over time.

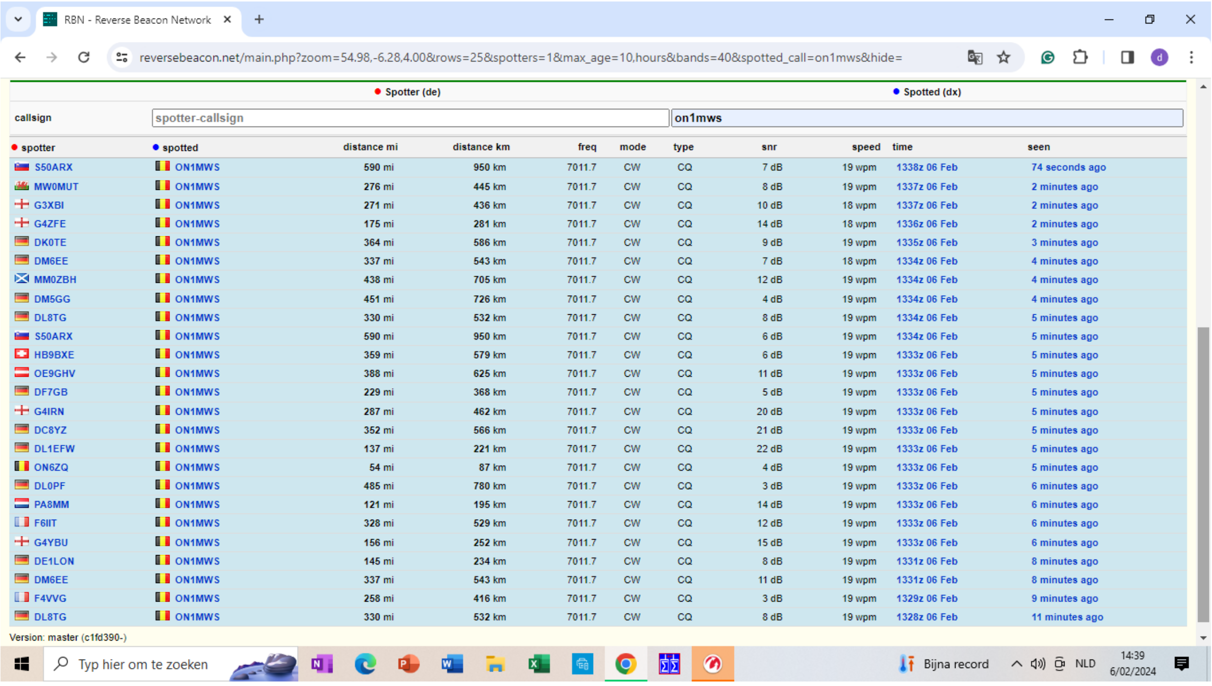
Now I have 3 SUSIs running for over 2 years now I am confident on how to avoid the annoying ‘integrator is full’ glitch. The glitch only happens if the coupling between the SUSI varicap and tank circuit is too small. I recommend using a trim capacitor for this coupling so it is easy to adjust. The integrator will try to increase the frequency, if necessary, but will fall short and fill up the integrator capacitor before the desired frequency is reached if the coupling between varicap and tank circuit is too small.

SUSI struggles to keep frequency up/integrator already on maximum speed= more coupling between varicap and tank circuit needed.

11) SUSI runs loose in the wild!

And above the new CW rig. It does not look like any transceiver you have ever seen, but as it is a one-off homebrew set, it might as well be unique. Years ago I saw a BBC documentary about the first transatlantic cables. I remember the building on the British coast where the messages used to be received and decoded. Now it is a museum. All the stuff looked weird but beautiful at the same time. I guess this rig could be put there and no one would notice. After posting it on the FB group 'the art HAM radio homebrew' Steve Fabricant noted 'It could be a radiosonde that they sent down from a saucer to detect intelligent life, and failed.' LOL, maybe I did overdo it?

First test was an automatic CQ run on RBN. Always fun to see where you get, but this time I'm very interested in the frequency readout my spotters will give me over time.



spotter	spotted	distance mi	distance km	freq	mode	type	snr	speed	time	seen
S50ARX	ON1MWS	590 mi	950 km	7011.7	CW	CQ	7 dB	19 wpm	1338z 06 Feb	74 seconds ago
MW0MUT	ON1MWS	276 mi	445 km	7011.7	CW	CQ	8 dB	19 wpm	1337z 06 Feb	2 minutes ago
G3XBI	ON1MWS	271 mi	436 km	7011.7	CW	CQ	10 dB	18 wpm	1337z 06 Feb	2 minutes ago
G4ZFE	ON1MWS	175 mi	281 km	7011.7	CW	CQ	14 dB	18 wpm	1336z 06 Feb	2 minutes ago
DK0TE	ON1MWS	364 mi	586 km	7011.7	CW	CQ	9 dB	19 wpm	1335z 06 Feb	3 minutes ago
DM6EE	ON1MWS	337 mi	543 km	7011.7	CW	CQ	7 dB	18 wpm	1334z 06 Feb	4 minutes ago
MM0ZBH	ON1MWS	438 mi	705 km	7011.7	CW	CQ	12 dB	19 wpm	1334z 06 Feb	4 minutes ago
DM5GG	ON1MWS	451 mi	726 km	7011.7	CW	CQ	4 dB	19 wpm	1334z 06 Feb	4 minutes ago
DL8TG	ON1MWS	330 mi	532 km	7011.7	CW	CQ	8 dB	19 wpm	1334z 06 Feb	5 minutes ago
S50ARX	ON1MWS	590 mi	950 km	7011.7	CW	CQ	6 dB	19 wpm	1334z 06 Feb	5 minutes ago
HB9BXE	ON1MWS	359 mi	579 km	7011.7	CW	CQ	6 dB	19 wpm	1333z 06 Feb	5 minutes ago
OE9GHV	ON1MWS	388 mi	625 km	7011.7	CW	CQ	11 dB	19 wpm	1333z 06 Feb	5 minutes ago
DF7GB	ON1MWS	229 mi	368 km	7011.7	CW	CQ	5 dB	19 wpm	1333z 06 Feb	5 minutes ago
G4IRN	ON1MWS	287 mi	462 km	7011.7	CW	CQ	20 dB	19 wpm	1333z 06 Feb	5 minutes ago
DC8YZ	ON1MWS	352 mi	566 km	7011.7	CW	CQ	21 dB	19 wpm	1333z 06 Feb	5 minutes ago
DL1EFW	ON1MWS	137 mi	221 km	7011.7	CW	CQ	22 dB	19 wpm	1333z 06 Feb	5 minutes ago
ON6ZQ	ON1MWS	54 mi	87 km	7011.7	CW	CQ	4 dB	19 wpm	1333z 06 Feb	5 minutes ago
DL0PF	ON1MWS	485 mi	780 km	7011.7	CW	CQ	3 dB	19 wpm	1333z 06 Feb	6 minutes ago
PA8MM	ON1MWS	121 mi	195 km	7011.7	CW	CQ	14 dB	19 wpm	1333z 06 Feb	6 minutes ago
F6IIT	ON1MWS	328 mi	529 km	7011.7	CW	CQ	12 dB	19 wpm	1333z 06 Feb	6 minutes ago
G4YBU	ON1MWS	156 mi	252 km	7011.7	CW	CQ	15 dB	19 wpm	1333z 06 Feb	6 minutes ago
DE1LON	ON1MWS	145 mi	234 km	7011.7	CW	CQ	8 dB	19 wpm	1331z 06 Feb	8 minutes ago
DM6EE	ON1MWS	337 mi	543 km	7011.7	CW	CQ	11 dB	19 wpm	1331z 06 Feb	8 minutes ago
F4VVG	ON1MWS	258 mi	416 km	7011.7	CW	CQ	3 dB	19 wpm	1329z 06 Feb	9 minutes ago
DL8TG	ON1MWS	330 mi	532 km	7011.7	CW	CQ	8 dB	19 wpm	1328z 06 Feb	11 minutes ago

The frequency I'm transmitting on is according to everybody 7011,7 KHZ. And more importantly, over the whole 11 minute run it stays 7011,7 KHZ. The proof that the SUSI stabilizer is working fabulously.

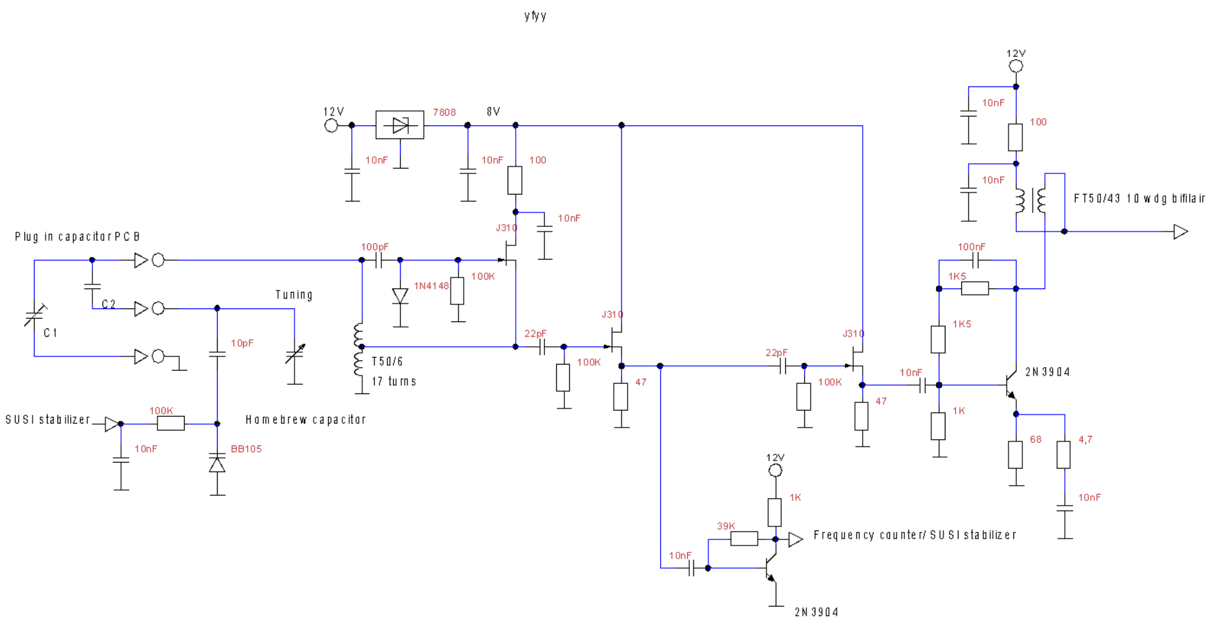
A week later I started to try QSOs with the new rig.

The QSL cards make it official.

12) Hidden in plain sight.

Okay, all is well… except that now my SSB transceiver sticks out like a sore thumb compared to the rest of my station. Time to rebuild it in the same style as my general coverage receiver, holiday radio and CW rig. The knackered SSB rig works well excluding that it sometimes runs off after a T/R switch. Thanks to the CW rig I might know the solution, a oscillator buffer amplifier with 2 J310's instead of 1. The old set uses an elaborate Huff and Puff circuit. Took me all of 2019 to build. It was a lot of fun to build and it must be one of the only one actually working oscillator/H&P combo's in the world. At first I was not planning to replace it during the rebuild.

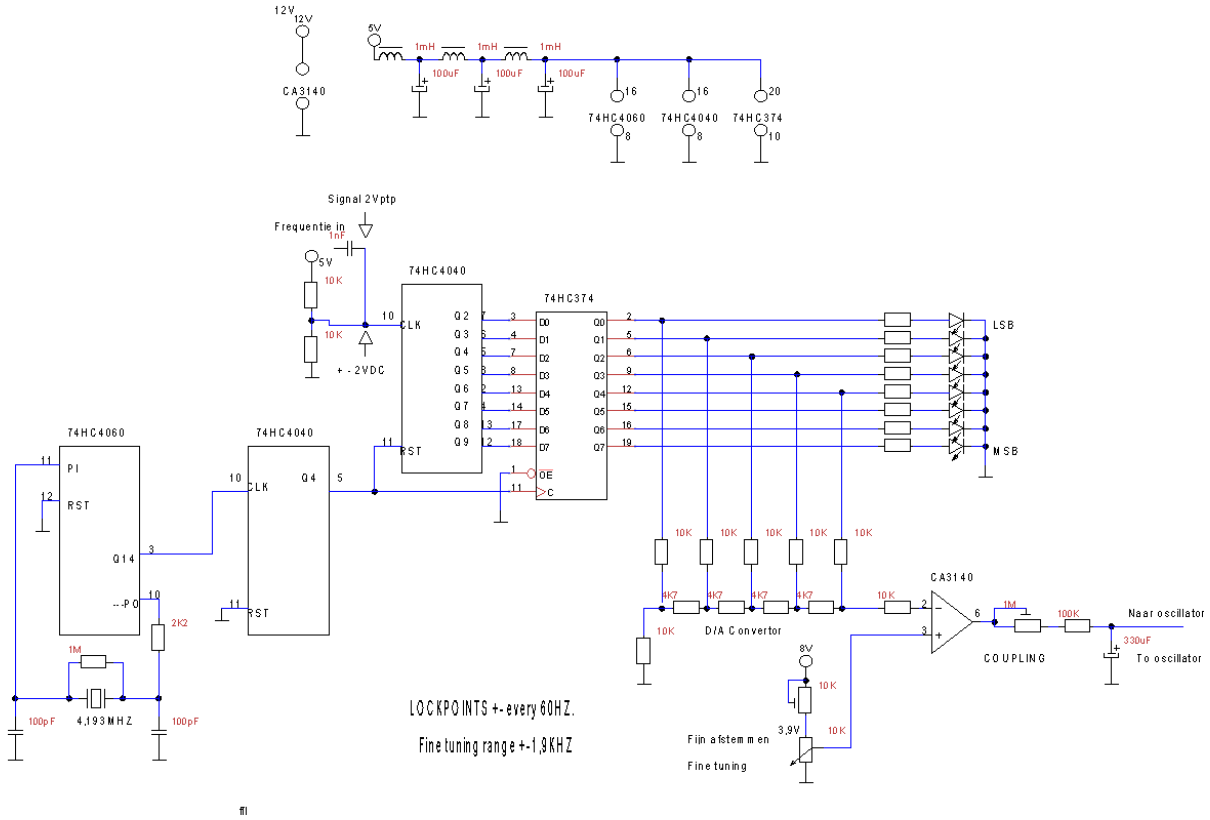
However… At one point I was relocating the CW rig during reception and naturally, the oscillator drifted away. It soon came back on frequency without doing anything. A H&P can't do that. When it drifts off it drifts off. That did it. The old H&P must go and be replaced by a SUSI. It's more stable, easier and has less components.



The oscillator is very similar to the one of the CW rig. This oscillator has a real varicap diode instead of a rectifier diode for the SUSI voltage. It also features a homebrew capacitor. It is simpler and has a much better design. It is basically a M8 threaded rod that is driven in or out of a metal tube with an inner diameter of 12mm. The tube is 60 mm long. Capacitance is around 10PF. The gear reduction is again provided by a steel girder bracket. Reduction is 54/1.

This homebrew capacitor has no frictional part and is just as good as a commercial one.

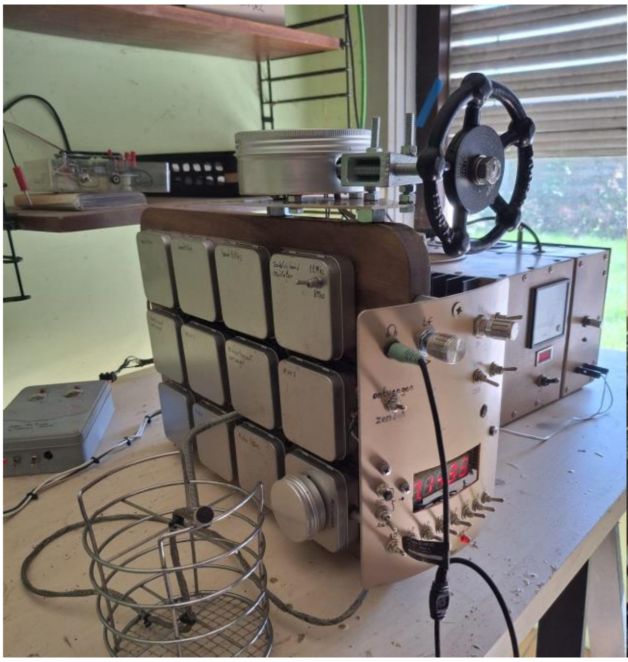
The stabilizer must be familiar by now. I built the 8 bit version and experimented. The 5 bit stabilizer was perfect. Every bit is about 60HZ. So 5 bit is 32X60= 1,9 Khz finetuning.



Frequentie stabelisator on1mws

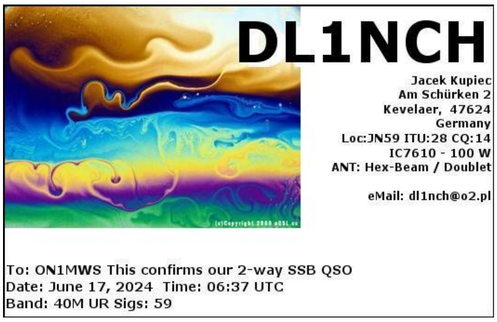
The resistor D/A convertor can be expanded or decreased by just adding or subtracting resistors. When your finetuning matches the normal bandwidth of your signal, you have a very practical tuning. I tried 6 bit and it was also possible, but I liked a smaller fine tuning.

The integration time is less critical for SSB. If the stabilizer is regulating fast you will immediately hear it with CW. In the SSB set, the time is much quicker than on the CW rig. If I can't hear it, my receivers won't hear it. So far no complaints.



The rebuilt SSB rig has a ‘real’ frequency counter. So you don’t need to see the SUSI LEDs to tune. You could simply leave them out. I decided to keep them for diagnostic reasons. They are hidden in a separate box. That way, I have a quick tool to check what the circuit is doing, if there is a problem.

For 40M, the oscillator frequency is about +18Mhz, for 20M it is +25Mhz. Which is the highest frequency the rig runs on. All other bands are upconverted.



13) **Goldilocks**.

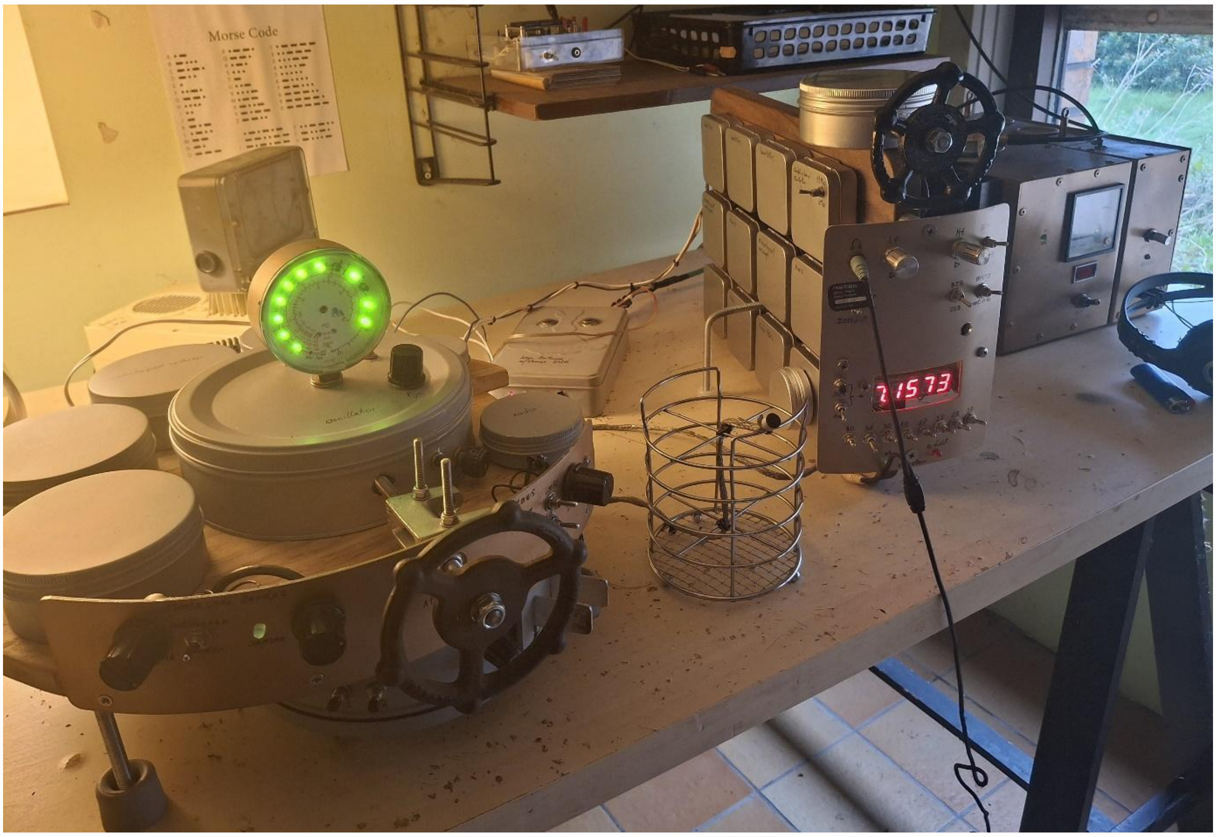
A first lock was quickly acquired after first turning on. The Goldilocks values for the integrator seem to be about 470K/1M and 220uF/330uF. All three of my stabilizers have about the same values.

The Goldilocks value for coupling the SUSI varicap to the main tuning capacitor seems to be around 10pF. Use a trim capacitor for that. Using a fixed value capacitor goes wrong quickly.

14) Verdict.

The SUSI oscillator stabilizer is absolutely no match for a modern DDS circuit and there is no point building it anno 2024. This circuit would have been a hit in the 1970s.

Nevertheless, making QSOs with a homebrew free running oscillator, combined with a unique simple stabilizer gives you more fun and sense of accomplishment than any modern DDS kit can ever give you.



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