X-Lock-ing the Kuhne 10GHz G2 transverter

28 November 2010

This web page and the **X-Lock-ing the Kuhne 1296 MHz G2 transverter page (/~vk4adc/web/index.php/general-projects/34-frequency-stabilisation/84-xlocking-kune-1296.html)** have some of the same content, particularly in the introductory areas. The reason for that is because both the 1296 MHz (23cm) and 10 GHz (3cm) G2 products from Kuhne use the same oscillator circuit and only the crystal frequency differs. The 1296 version uses 96.000 while the 10 GHz version uses 106.500. If you read one page, you might not read the other so the relevant content has been duplicated on each page, edited as necessary to reflect the model.

The older G2 units drift in frequency so later model G3 units now have an internal locking circuit to stabilise the oscillators. If you have an old version, can the same idea be applied ? Yes, it can. While it wasn't my transverter that needed to have the frequency drift corrected on, it was my X-Locker design that made it possible.

First some background. I have been working on a project that I have called **X-Locker (page here (/~vk4adc/web/index.php/general-projects/34-frequency-stabilisation/80-xlocker1.html))** , and it's purpose is to frequency-lock local oscillators in transverters back to a 10.000 MHz standard. Of course, it could be used for other purposes too but this was it's primary target.

It uses fairly standard phase lock loop (PLL) principles but uses a pre-programmed PICAXE on the PCB to set up the PLL chip to work on a specific frequency. When I say pre-programmed, it is configured individually for a specific frequency - and that is not an end-user programming option. It has to be supplied set up for a specific frequency and in this application, it is 106.500000 MHz.

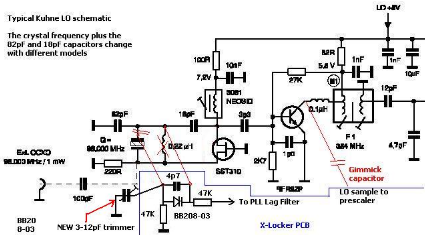
This 10GHz transverter frequency multiplies the oscillator frequency by 96 so the 106.500000 should become 10224.000000 MHz - or 10.224 GHz. That assumes that it is on-frequency. As supplied, the actual frequency could be several kilohertz off frequency so at 10 GHz, that means a frequency error of maybe 300 KHz. While that doesn't seem like much given the frequency, if you are using single sideband (SSB) then you just aren't in the race to be "found".

The complication is that the frequency error is not constant. As the transverter unit itself warms up, it will change frequency - and will continue to do so for a long while. That makes knowing where to look for a given station on a given frequency somewhat problematic.

The next complication is that there is no direct frequency adjustment (or "netting") option on these devices. The frequency varies as you tune the "slug" in the LC-tank coil but you tune that for maximum "drive" to the next frequency multiplier stage - and not for the correct frequency.

To solve the drift - and the initial frequency error to to the LC-tank tuning, we can "lock" the oscillator to a stable frequency standard at 10.00000 MHz using PLL techniques.

My X-Locker project takes this 10 MHz reference signal to stabilise an external oscillator circuit (in this case, it is the crystal oscillator built into the G2) and hold it on-frequency using a variable capacitance diode ("varicap"). It does this by changing the applied voltage as it senses a frequency change (eg from drift due to temperature).

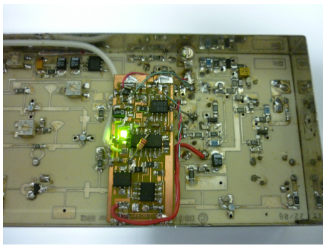
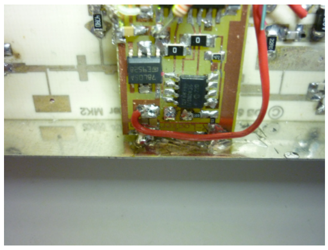


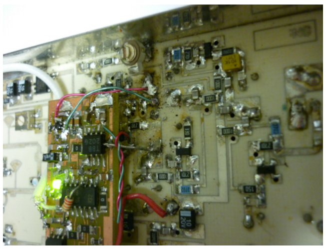
{ Mouse over for larger view}

*** Note that the BB208-03 varicap diode shown above has been replaced by a higher-capacitance series to provide a greater frequency control range.

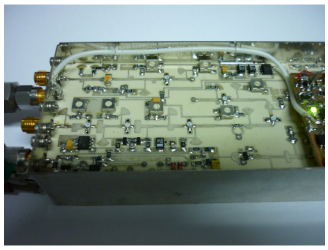
This schematic shows how the original G2 oscillator circuit was modified. Just one track on the PCB needs to be cut. The extra components are all on the X-Locker PCB except for a 3-12 pF trimmer.

The following photos provide some indication of how I "X-Locked" a 10 GHz G2 transverter using a version 2B X-Locker PCB.

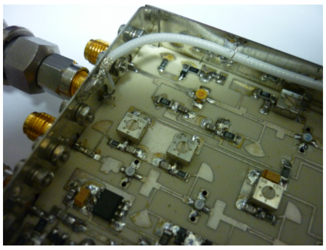
 This is the X-Locker version 2b PCB mounted in the underneath of the G2 case.	 Mounting is relatively easy. The inside surface of the tinplate box is "tinned" with solder, along with some of the edge of the PCB and it is simply soldered to the inside of the box



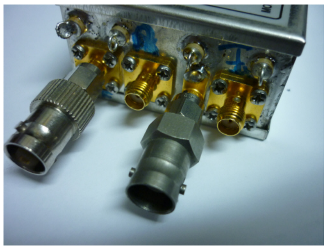
This shows the four "signal" connections to the G2 PCB. The red wire at bottom middle is the positive power supply, in this case +8V. Along the edge of the PCB, you will note two wires just twisted together - these form a "gimmick" capacitor to feed a sample from the local oscillator path to the prescaler input on the X-Locker. The "earth" wire is just a fairly stiff tinned copper wire and it serves 2 purposes - physical stabilisation and and additional earth point for the outer end of the PCB. You will see above it is a thin green wire. This goes to the junction point of the 82pF and the 22pF AFTER the PCB track to the crystal termination point has been cut - just with a fine / sharp knife blade. The final wire is the thin red one that goes to the crystal terminal that was just separated from the capacitor termination point.
Finally right at top centre is a new 3-12pF ceramic trimmer used for frequency adjustment. The thin red & green wires used are actually wire-wrap wire - it's thin & fairly heat insensitive.



The X-Locker requires the 10 MHz frequency reference signal applied too - on the third edge of the PCB. It is fed via a teflon-series coax held in place with thin wire saddles soldered to the inside edge of the tinplate box.



The coax terminates on the centre pin of another SMA female connector fitted into the "spare" space on the end of the box, with the shield being soldered to the inside of the box..



This shows the 2-screw SMA connector fitted in the available gap. Note that it is soldered onto the tinplate end. BNC to SMA adapters aren't the greatest at microwave but the two in this photo are used at 10 MHz (centre) and 144 MHz (LHS).

The bottom of the box is sealed off by a tightly fitting tinplate lid lined with a RF absorption foam material. To prevent inadvertent connection to the X-Locker PCB, the foam was covered by a piece of plastic packaging tape. The indentations seen towards the RHS are from where the components on the X-Locker have made physical contact.

The completed box looks much the same as any other G2 version - except for the additional SMA female socket on the end.

A definitive "tuning" methodology has yet to be created. A general guide is that you power up the G2 board but not the X-Locker. Set the 3-12pF trimmer to the mid-position (half capacity). You tune the LC-tank until you have the oscillator working and somewhere near the correct frequency.

Next you apply the 10 MHz reference signal and the +8V supply. You need to monitor the phase discriminator (PD) test point with a DMM on the 10V range as well as measuring the frequency.

The lock led on the PCB will go quite bright when the PLL is locked and you need to re-trim the LC-tank until it does go bright. If you don't have any 10 MHz reference applied, it never goes bright.

Adjust the trimmer slowly while observing the PD test point and it should go from a low voltage of about +0.5 / +0.6 volt up to just under +5.0 volts somewhere through it's range. Try to find a setting that gives a final voltage between +1.0 and +2.0 volts so the varicap provides a good control range.

If you can't get the voltage within the desired 1-2 volt range, adjust the LC-tank slug in or out a little and try varying the trimmer again. The tip here is to do the adjustments s-l-o-w-l-y. Adjust and wait.

I will finalise the process and provide more details in due course.

An observation : when any G2 is first powered up (and the X-Locker with it), it can take up to 20 - 30 seconds (or more depending on ambient temperature) for the X-Locker to actually lock to frequency. I suspect that it is the crystal heater bringing the crystal up to temperature and thence into actual lock range. I suspect that by using two varicaps in parallel on the PCB, I would be able to lock over a wider range and there is almost enough room on the board to do this....

After having success with these modifications, I have made an alteration to the latest X-Locker PCB layout so that it is easier to configure for the Kuhne series transverters. The new layout is coded "Version 2C".

Before you ask, no I don't have a price or availability YET.