10 MHz Reference with GPS Switch

Automatically switches from OCXO to GPS

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Frequency accuracy and stability is important for microwave operation, especially for long distance contacts, which are the interesting ones. A signal may only appear on infrequent QSB peaks for just long enough to copy an exchange; if you are still hunting for a signal, you've missed it. Digital modes, if you are using them, also require accurate frequency.

Many stations today use frequency synthesizers as LO sources, so the frequency control is based on a reference oscillator, usually 10 MHz. A good OCXO, after warmup, can do a good job, but I prefer locking to GPS for less uncertainty. The problem with GPS is that it takes a while to acquire satellites and lock the 10 MHz reference oscillator.

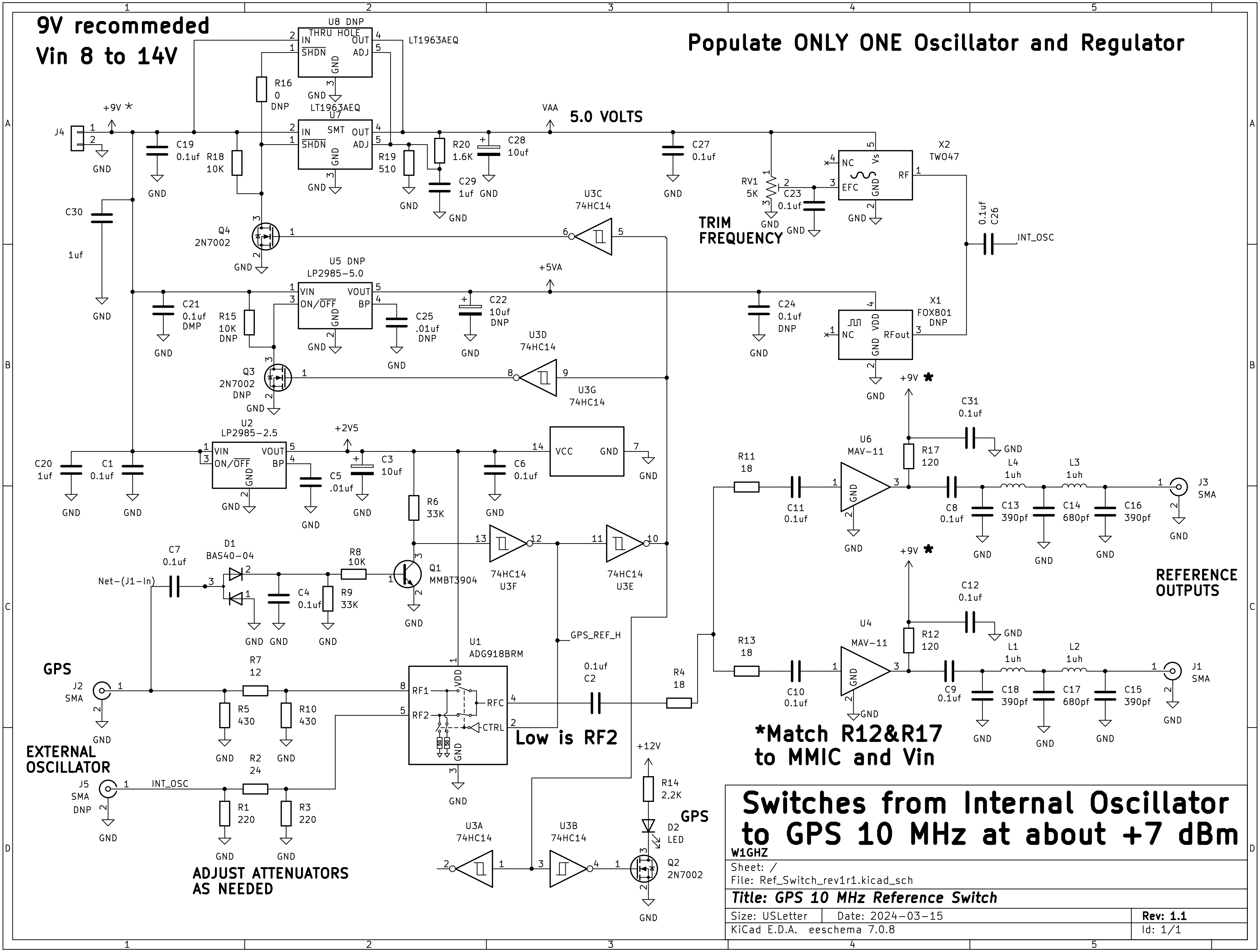
For a rover station, the GPS delay can be a problem. When arriving at a site, we would like to work other rover stations before they move – there is always one ready to pack up. Waiting for the GPS causes a delay for everyone and may result in missed contacts. Having a reference that is ready to go would be better; at least some of these contacts are shorter distances and could be managed with some frequency ambiguity.

Last summer, I tried operating with both an OCXO and a GPS reference, using the OCXO at startup to be within a few KHz and switching to the GPS after it locked. This took three boxes: the OCXO, the GPS reference, and a splitter for the 10 and 24 GHz transverters, plus the GPS antenna. Switching was done by moving cables. This arrangement worked but certainly needed improvement.

Reference switch

While I was considering this problem, Brian, WA1ZMS, was dumpster diving and found some very good OCXOs – small and operating at 5 volts. He gave a couple to me and to Mike, N1JEZ, to play with. I sketched out a switch that would automatically switch to a GPS signal when available and turn off the OCXO – having two oscillators running at almost the same frequency can confuse the synthesizer PLL with uncertain results. (Some synthesizers have a reference input but fail to turn off the internal oscillator.)

I started to lay out a PC board and decided that this was good time to learn KiCAD, a more modern design program. There was a bit of a learning curve, but it has advanced features that prevented a few errors, so the first prototypes worked without the usual patches.



Switches from Internal Oscillator to GPS 10 MHz at about +7 dBm

W1GHZ

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File: Ref_Switch_rev1r1.kicad_sch

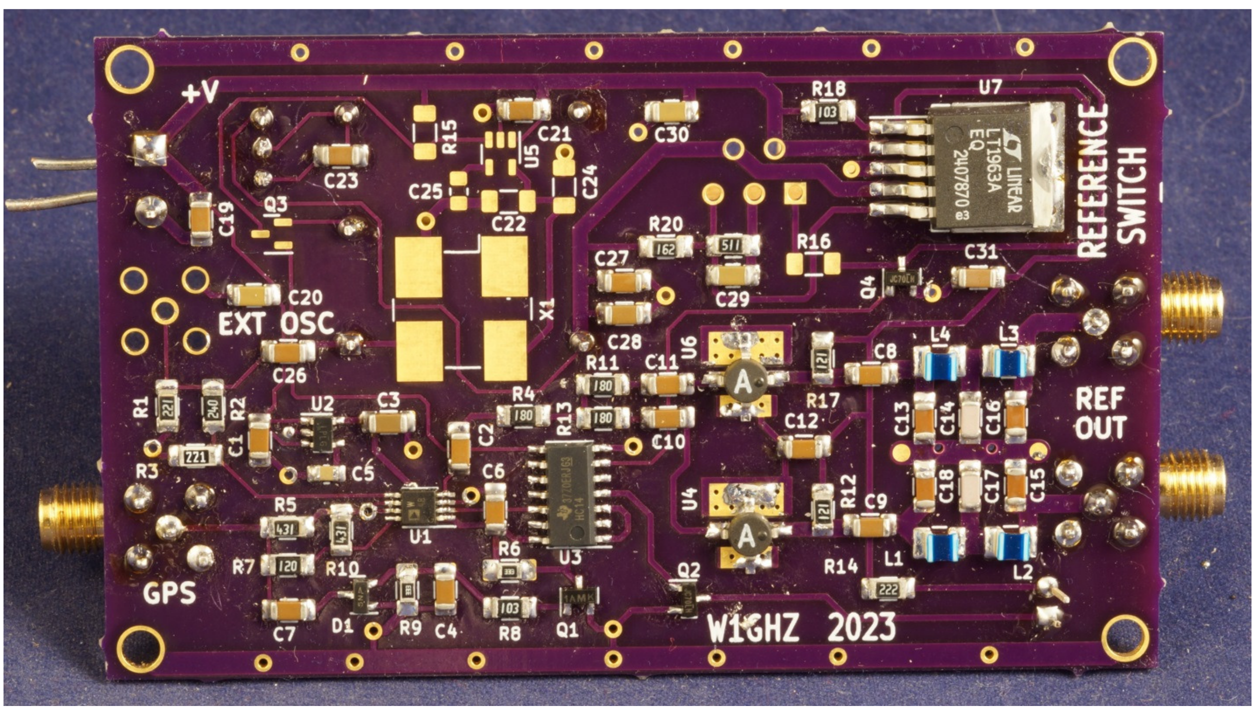
Title: GPS 10 MHz Reference Switch

Size: USLetter	Date: 2024-03-15	Rev: 1.1
KiCad E.D.A. eeschema 7.0.8		Id: 1/1

The prototype board switched from the OCXO to the external GPS-derived 10 MHz, but it wasn't sensitive enough, requiring more than 10 dBm before it switched. This is more than the output level from a typical GPS reference, so a small design change was required. The unit now switches at +7 dBm and the LED lights. The PC boards incorporate this change.

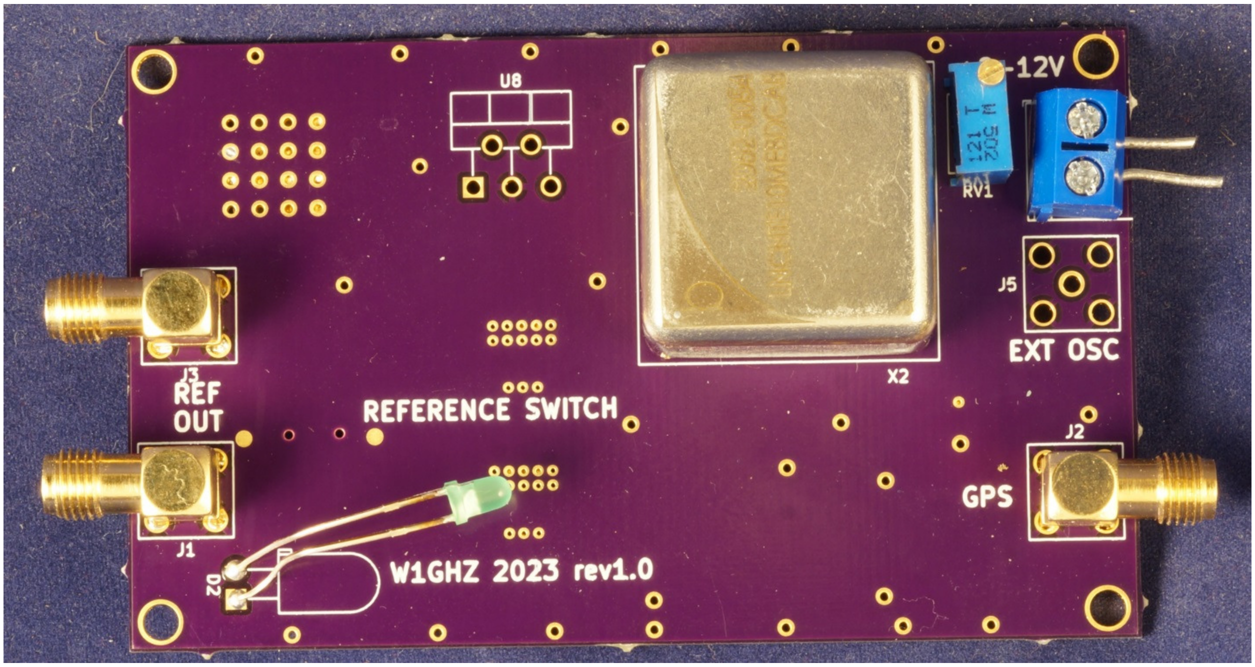
The final design, with the schematic diagram shown in Figure 1, switches at +7 dBm, and has two 10 MHz outputs with low-pass filtering to provide a clean sine wave output. It has a low-noise voltage regulator for the OCXO to reduce phase noise. The switching is done by an RF switch chip with high isolation, unnecessary if the OCXO is turned off, but one might choose to leave the OCXO running for stability. A slight complication was that the chip runs on 2.5 volts, requiring an additional voltage regulator, so all the switching logic runs at 2.5 volts.

I made a couple of design choices; yours might be different. The input attenuators are chosen so that the output level changes very little when switching between 10 MHz sources. The other choice was to make the input voltage +9 volts, after I discovered that the OCXO draws more than ½ amp at startup and the voltage regulator was getting hot. I did include a footprint for a thru-hole voltage regulator that could be attached to a good heatsink, if 12 volt operation is desired. The bias resistors for the output MMICs would need adjustment as well.



Everything on the board is surface-mount, as seen in Figure 2, except the OCXO and the trimpot for fine frequency adjustment. Those are on the back of the board, shown in Figure 3. All components are identified on the board. I chose larger 1206 size components for ease of soldering, but some of the ICs are tiny, but they have leads, so I was able to hand solder the prototype. (Hint – use solderwick to remove excess solder so leads aren't shorted.)

There is also one off-board component, not shown: Brian found an oscillation at about 6.7 KHz (I can't hear that frequency) until the oscillator warms up. Putting a large capacitor, 330 µF or more, across the input voltage tames it (C99 on schematic).



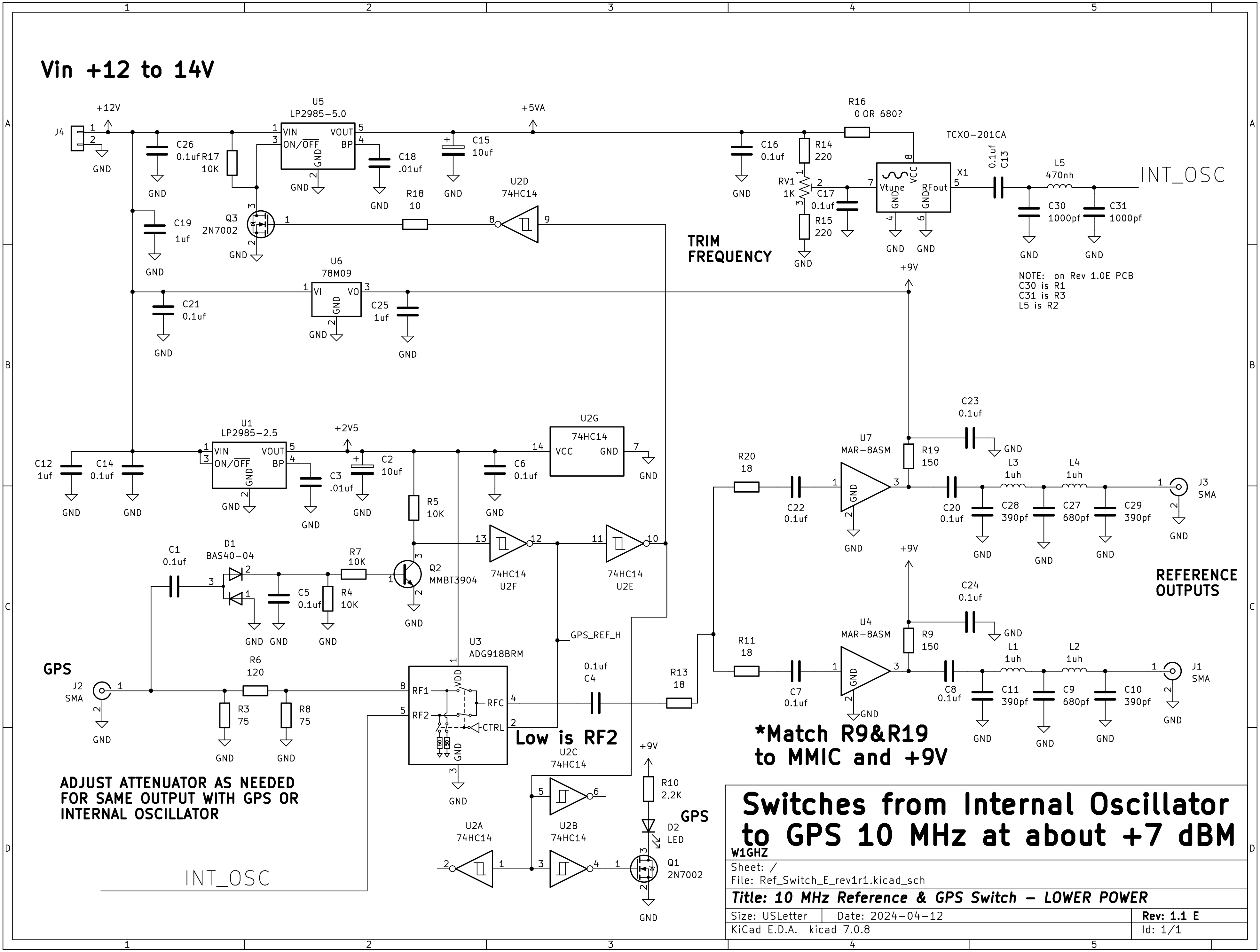
Mike, N1JEZ, found it easier to assemble boards using his toaster oven to solder the SMT parts all at once, so he assembled two boards so we could give one to Brian as thanks for the OCXOs.

Since this OCXO is not readily available, I also included a footprint for a common SMD oscillator, and an SMA input for an external OCXO. If you would like to have a different OCXO on the board, I can provide the KiCAD files for you to modify and make any other changes.

Lower Power 10 MHz GPS Reference Switch with Alternative Oscillator

When I searched for a 10 MHz oscillator with the common footprint, I found none with good frequency accuracy. Then I consulted Steve, N2CEI, at Down East Microwave. He had some that are pretty good and sent a few. These have yet another footprint. I adjusted one to exactly 10 MHz and ran it for a few days and it stayed within 1 or 2 Hz.

I modified the PC layout for the new oscillator and a smaller low-noise voltage regulator. The new schematic is Figure 4. The new oscillator draws very little power but has a much lower output level, especially driving 50 ohms. I found that following it with a simple low-pass filter yielded a modest output level and clean waveform. The low level meant that more gain is required in the output MMICs. I chose the MAR-8ASM+ — the data sheet says it has improved stability compared to the old MAR-8. The GPS input attenuator needed higher attenuation so that the output level changes very little when switching between 10 MHz sources.



Switches from Internal Oscillator to GPS 10 MHz at about +7 dBM

W1GHZ

Sheet: /

File: Ref_Switch_E_rev1r1.kicad_sch

Title: 10 MHz Reference & GPS Switch - LOWER POWER

Size: USLetter | Date: 2024-04-12 | **Rev: 1.1 E**

KiCad E.D.A. kicad 7.0.8 | Id: 1/1

This version runs fine with input voltage from 12 to 15 volts, drawing only around 100 mA, so a rover could easily leave it running constantly for a pretty good 10 MHz reference, switching to GPS reference when needed. A trimpot can adjust the oscillator frequency right on.

The finished board is shown in Figure 5, with no components on the far side. PC boards and oscillators for this version are available.