2.4 GHz & 3.4 GHz Transverter Ideas

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This article is not a concise "how-to-build-it" but actually covers the background as to "why do it this way", with the "how to do it" later in a different web article.

The Background - or - the "Why" ....

Elsewhere on this site you will find a web page dealing with a **Coffee Can Dual Band Antenna Feed (/~vk4adc/web/index.php/vhfuhf-projects?task=view&id=121)** for these same two amateur bands. Of course, to be able to use these frequencies, you actually have to have equipment that will operate up there. This web page deals with my concerns and approach.

Before we get into some of the other technicalities, this extract from the official WIA Band Plan provides a guide as to where in this part of the radio spectrum the amateur operations should take place :

WIA - Australian Amateur Band Plans - updated 5/04/2011 Page 17

13 cm Band - 2300 - 2302 MHz Advanced licensees only

2400 - 2450 MHz Advanced & Standard licensees

2300.000 - 2302.000 NARROW BAND MODES *(Note 1)*

2400.000 - 2403.000 AMATEUR SATELLITES *(Note 3)*

2403.000 - 2406.000 NARROW BAND MODES *(Note 1)*

2403.000 - 2403.100 EME only

2403.100 - 2403.400 CW / SSB

2403.100 Calling frequency: national primary

2403.200 Calling frequency: national secondary

... continuing

Note 1: Narrow Band Modes

This segment is reserved for modes such as CW, digital modes and SSB with bandwidths up to 4 kHz. Weak signal operation has absolute priority. Calling frequencies should be used only to make initial contact and then vacated as soon as possible. Please avoid any terrestrial operation within the EME segment. The "Digital DX modes" segment includes recommended spot frequencies for SSB-based digital modes, on the same pattern as in Note 1 of the 2 metre band plan.

The 2403 MHz segment may have to be moved if required by future amateur satellite allocations. The 2424 MHz segment is reserved for possible use for EME contacts with Japan and New Zealand, which have their weak signal segments in this part of the band.

The segment 2300 - 2302 MHz is recommended for use in areas where the weak signal segment on 2403 MHz suffers unacceptable interference from digital links and other devices, and also for crossband EME contacts with overseas stations operating on 2304 MHz.

9 Cm Band - Advanced licensees only

3400.000 - 3402.000 NARROW BAND MODES (Note 1)

3400.000 - 3400.100 EME only

3400.100 - 3400.400 CW / SSB

3400.100 Calling frequency: national primary

3400.200 Calling frequency: national secondary

The Band Plan thus puts the current 2.4GHz amateur segment used in Australia for SSB as 2403.100 calling, 2403.150 for contests working etc, & at 3.4 GHz the frequencies needed are 3400.100 calling, 3400.150 for contests working etc. The importance of these frequencies will become evident shortly.

Back now to transverters... These devices use a VHF or UHF multimode transceiver as an "I.F." (Intermediate Frequency - IF) device on both transmit and receive. This means that the IF is up-converted to the output frequency on transmit and the incoming signals are down-converted to the IF on receive. For operation at our desired operating frequency/ies, that means we use frequency mixing processes against a Local Oscillator (LO) signal that is below the desired incoming frequency by the magnitude of the IF. So, 2403.100 - 145.100 = 2258 .000 MHz and 3400.1 - 145.100 = 3255 MHz. We call this "low side injection" and use it so that as the IF transceiver is raised in frequency, the receive/output frequency also shifts up in frequency by the same amount. That makes a coordinated shift of frequency a little easier as the dial readout is simply shifted (usually just in the operator's mind) up to the new final frequency.

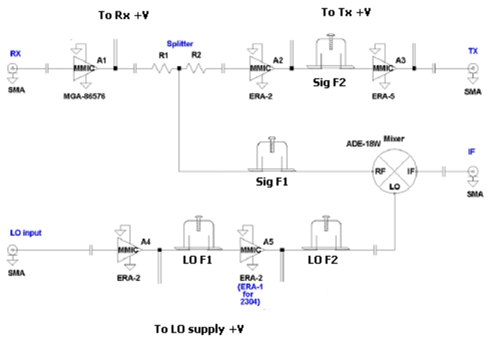
The 145.100 MHz IF has been chosen to avoid some of the issues that occur when other equipment is operated on the "2 metre band" - particularly with SSB activity on 144.100 / 144.150/ ..... By spacing the frequency up 1.0 MHz (or more), some measure of isolation from overload interference occurs. A further shift up to 146.100 / 146.150 is usually avoided as the commonly used FM frequencies are 146.500 / 146.525 / 146.550 etc so would again be close to the IF and overload/breakthrough will occur with that equipment too.

We now know the main frequencies to be used in the final arrangements : around 145 MHz for the IF, 2258 or 3255 MHz for the LO (depending on which transverter is the focus) and the actual input/output frequency at either 2403 or 3400 MHz.

There are some transverter PCBs for 2.4, 3.4, 5.7 and 10 GHz around in Australia at the moment based on a design implemented by Graham VK3XDK. In my view, it is unfortunate that the 3XDK design for 2.4 GHz uses SAW filters to obtain the RF selectivity because, while there are SAW filters available for 2400 MHz operation, there are none manufactured that cover the 2300 MHz segment. The next-lower SAWs finish around the low-2200 MHz area. This is a design limitation (again, in my view) because if you re-read the Band Plan Note (1) above, you will see that the 2400 MHz Plan is not set in stone - and users can suffer badly from interference from one, or more, of the many Wireless LAN systems (WLANs) due to the proximity of the WLAN band - starting around 2412 MHz - and these use wide-bandwidth spread-spectrum emissions. We may want to shift to a quieter segment and the 3XDK 2.4 GHz transverter simply can't be made to go there.

I want to be able to operate my 2.4 GHz transverter in whichever part of the spectrum is relevant to my requirements (2300-2302 or 2400-2450) so the idea of an inflexible SAW doesn't suit. I did a fair bit of research on alternatives and quite like the "pipe-cap" filter arrangement promulgated by Paul W1GHZ in his "rover" series of transverters. These can be tuned for either portion of the spectrum - 2300 or 2400 - but not providing simultaneous coverage of both due to pipe-cap filter bandwidth limitations.

W1GHZ 2.4/3.4 BLOCK :



The **W1GHZ transverter concept** is simple. In the receive mode, the unfiltered receive frequency is amplified in an MGA86576 MMIC (23dB gain, NF = 1.6dB) (denoted A1) and then fed to a simple resistive splitter thence to "Sig F1" pipe-cap filter and then to a ADE-18W mixer then to the IF port. On transmit, the IF signal is mixed up to the signal frequency, filtered by the "Sig F1" filter (but in the reverse direction), into the splitter and then into MMIC amplifier A2, via "Sig F2" filter to amplifier A3 and then to the transmit output port.

The LO signal is fed into amplifier A4, which is overdriven and generates significant levels of harmonics, then via pipe-cap "LO F1" to select just the desired harmonic (i.e. 3rd for 2.4, 5th for 3.4) into amplifier A5 and then into the "LO F2" filter to supply the mixer port with a "clean" (of noise and harmonics) local oscillator signal.

The use of pipe-cap filters means that it can be retuned anywhere the pipe-caps can tune. That includes 2300, 2400, 3400 and maybe just slightly higher, as well as in between

Mark at Minikits (http://www.minikits.com.au/) has small quantities of the 1-1/8" copper pipe-caps available (to suit 1" OD copper pipe) at around $AUD3 each (at the moment) and a few phone calls to normal gas component and plumbing parts suppliers around town indicates that they can supply them (they call them brazed & soldered pipe-ends) at around $7-$10 each - if you are in a hurry.

Obviously, Mark can also supply most of the other mandatory parts to build up these types of devices - SMA connectors, MMICs, etc... as well as having his own brand of transverter kit available. There is a point to make note of if you are considering Mark's 2.4 GHz kit, from his transverter kits web page (http://www.minikits.com.au/kits3.html) : "Please Note: This Kit cannot be modified or used on 2304MHz" The kit does not use SAW technology but a rather sharp interdigital filter design on the PCB surface. His approach on the components used in building up a complete transverter (2.4 or 3.4) is quite flexible and should at least be considered.

I emailed Paul W1GHZ about the availability of the PCBs used in his rover and he quickly emailed back the current pricelist. I subsequently ordered two of the 2.3 / 3.4 GHz transverter PCBs plus 2 x LO PCBs (even though I didn't really plan to use these last two boards) at a total cost of $US57, including air mail.

If you are intrigued by the last comment about my not using Paul's LO PCB's, I plan to use my X-Locker V3 boards (uses a Melexis TH71221 synth chip) as the basic LO frequency generator at 752.6666 (2.4GHz) and 651.000 (3.4GHz) with frequency multiplications of 3 and 5 respectively. That gives the 2258 and 3255 MHz LO injection frequencies, all locked to an external 10.000 MHz TCXO. The V3 will produce up to +10dBm and the W1GHZ transverter PCBs require about +5dBm at approx 700 MHz at the LO input port. If there is an eventual frequency shift down to 2300 MHz (or other segment), the V3 board can be re-programmed down to provide 2155.000 MHz / 3 = 718.3333 MHz.

I had initially contemplated the 3XDK LO PCB (uses a Si4133 synth chip) for a while but found a limitation for my use : this LO steps only in whole MHz as implemented by the supplied software. I needed 752.666 - not 752 or 753 - and the chip doesn't go high enough in frequency to allow direct generation of 2258 MHz. Maybe the code could be altered to overcome this MHz-step limitation - I haven't looked closely enough at it plus the chipset command structure to confirm yes or no.

The W1GHZ transverter is said to produce in the order of +5 to +10 dBm output at the operating frequency but even 10 milliwatts (+10dBm) won't get too far. How do we get more transmitter power without it costing a fortune ? There is an eBay seller who runs a "shop" under the name "RF Basic Store (/ rfextra)", based in the USA, and he sells a fair variety of new microwave devices including :

RFMD 3.0-3.8GHz 2W InGap MMIC, SZP-3026Z, RoHS, Qty.2 - $US10

RFMD 0.7-2.2GHz 2W InGap MMIC, SPB-2026Z, RoHS, Qty.2 - $US8

PCB for RFMD/Sirenza SOF-26 RF MMIC Power Amp, Qty.2 - $US10

... and he ships to Australia.

By buying the PCB's plus some SZP-3026Z devices that cover 3.0-3.8 GHz (typical gain 12dB, PO up to +33.2dBm), that will hopefully cover the RF power side at 3.4 GHz. Unfortunately, the frequency range of the SPB-2026Z is quoted to 2.2 GHz (typical gain 13dB, PO up to +32.8dBm) but there is no RFMD device in the SOF-26 package available that will cover the 2.3-2.5 GHz spectrum - so this one will be a suck-it-and-see job at 2.4 GHz. The drive level requirements will be discussed in more detail later. The 2-pack PCB's means that there will be one board plus one MMIC for 2.4 and one plus one for 3.4 GHz, with a spare MMIC device for each band. Of course, these devices are not designed for SSB linear mode (even though quoted as "a high linearity single-stage class AB Heterojunction Bipolar Transistor (HBT)") use so driving them to their maximum output power is not appropriate. If I can get 1 watt of RF from each board, I will be happy. Note that with the antenna gain at 2.4 GHz (approx 24dBi) will make that power effectively >200 watts EIRP, a little more than that expected at 3.4 GHz (expected gain around 28-29dBi).

One watt = +30dBm, so a power amplifier device with a gain of 13dB needs around +17dBm drive to produce that. The transverters should produce between +5 and +10dBm so if we can introduce a broadband intermediate driver stage with a gain of around 10 to 13dB, we are right in the ball-park for getting our 1 watt of RF output. An ERA-5 MMIC has a gain of 16 to 19dB at these frequencies with an output level of about +19.6dBm. The ERA-6 MMIC has a gain of 11.5dB at these frequencies with an output level of about +18.5dBm. Either of these devices could be used as a driver, the ERA-5 probably the better choice. It is now mainly a matter of generating a physical PCB layout that will take one of these devices, make it fit in with the physical dimensions of the transverter PCB's and move on from there.

The final step is the matter of the antenna switching from transmit to receive and the sequencer to set up the timing of same. Minikits has a small PCB kit that mounts an Omron G6Z relay available, and that would suit but since I am already doing PCB artwork for the transmitter driver and X-Locker V3 parts of it, why not do my own version of that with dimensions to suit the physical aspects of the transverter ??? The sequencer has already been designed and tested and is described elsewhere on this web site : **web link (/~vk4adc/web/index.php/component/content/?task=view&id=48&Itemid=1).** The PCB artwork has already been done for the sequencer so it is simply a matter of creating a physical PCB from that. At this stage, the transverter concept planning all seems to be coming together.

The physical construction of the transverters will appear shortly as a separate topic.

Postscript :

23/5/2011 : I had an email in from Iain VK5ZD who suggested that replacing the MMIC's in the transmitter lineup with GALI-39+ and GALI-84+ respectively (both in SOT89 structures) would produce around +16dBm and thus provide closer to the drive level that the RFMD PA devices would require.. He also suggested that a thin copper shim be placed across the ground plane lands under the GALI-39+ to ensure stability. {The output stage already has a track on the PCB joining the two ground plane sections.} Thanks for tip Iain...