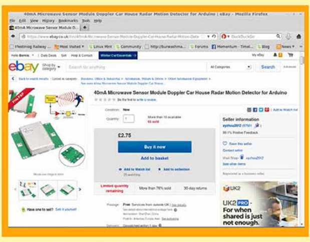
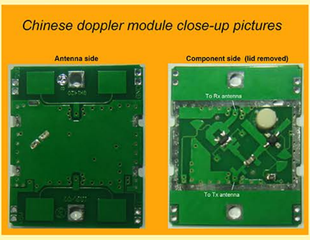
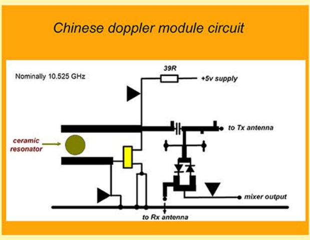


1. Using one of the low cost (under £3) Chinese doppler modules from Ebay, this picture shows all that is needed to manage a line-of-sight QSO over a 10km path. By adding a 45cm digidish to the LNB alone, the additional 20dB receive gain increases that potential range to 100km.

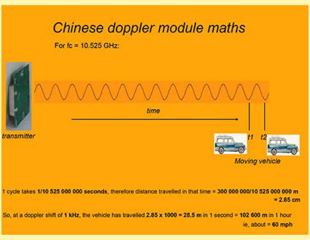
2. This is a typical current Ebay advert for one of the doppler modules. Expect to pay a little more from a UK supplier – though of course, the unit will have come from the same Far Eastern source.

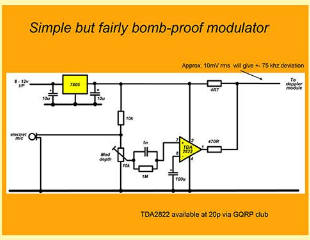




3. Here are top and bottom side views of the module, with the lid removed from the component side. Even counting the ceramic puck that controls the oscillation frequency, there are only five discrete components.
If you trace out the circuitry (next slide), you will find that is pretty much the same as an average satellite LNB oscillator and mixer stage. Note that no RF amplifiers are fitted, so receive sensitivity is some 10dB less than an LNB.
The oscillator transistor (an anonymous unmarked FET) can be seen on the RHS of the right hand picture, just below the circular white ceramic puck. Two coupled lines (at right angle to each other) around the puck provide the coupling between the FET and the puck.
RF from the oscillator comes away diagonally from top right towards bottom left and splits into two path immediately after the dc blocking capacitor. The straight path terminates at a plated through hole connection that feeds the two bottom square patch antennas that can be seen on the left hand picture. The second path at the split feeds across to the mixer device, which consists of two schottky diodes in one package. A half ring phasing section follows, with the receive pair of patch antennas coming in from the upper side via another plated through hole.
Mixer output is from the mid-point of the phasing section and feeds via the fan shaped track RF short circuit, which serves to remove any leakage oscillator signal that might have made it past the mixer.
Only the difference frequency between the oscillator mixer drive and the doppler shifted rx input makes it to the output solder pad.

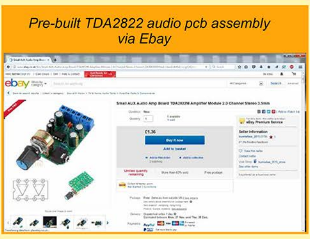
4. Here is the circuit diagram version of the previous slide. Note that there is a 39 ohm resistor in the supply connection to the oscillator FET. This serves to reduce the specfied 5v power source to about 3.5v, remembering that the device has a maximum drain voltage of noticeably less than 5v...
Following the various signal and oscillator RF tracks, any number of short tangential stub lines can be seen. These all perform impedance transforming functions and is one example of how 10 GHz design can be easier to perform than their VHF/UHF counterparts, so life isn't universally difficult at these microwave frequencies. Likewise the fan shaped tracks, which act as reasonably wideband quarter-wave decoupler sections, each one saving a decoupling capacitor that otherwise could have been used.
One thing to note with these doppler modules is that the tuning screw, which is steel, is self-tapped directly into the plunged hole in the aluminium lid. This is very crude and if the screw is adjusted more than a few times, the thread will wear to the point where the screw is loose and you won't be able to maintain a reliable frequency.
It makes sense, therefor, to decide on a common frequency of use within the 3cm band, and I would suggest 10.350GHz, since this is on the edge of the WBFM band plan and also is the same frequency as the reference used on the crystal controlled 'berniebox' converter box that some club member have. Thus, a satellite LNB plus tuneable IF can be tuned onto the reference (to calibrate the receiver) and the doppler module screw adjusted until it is also on frequency. It will require two or three turns in an anti-clockwise direction to achieve this.

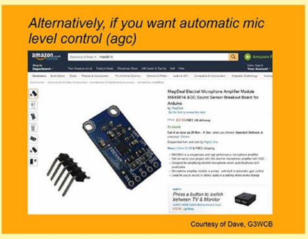




5. I thought it might be interesting to first contemplate the doppler module used in a typical application that it was designed for, and this was my rather tortuous attempt at calculating the amount of doppler shift that a vehicle moving tangentially away from a doppler module would experience. I'm sure there are much simpler (and possibly more accurate) descriptions available elsewhere, so apologies in advance (and more generally for my poor Secondary Modern spelling ability).
The drawing attempts to calculate how far the vehicle has to travel in one second to lose one cycle of RF – ie, a doppler shift (as experienced by the driver) of 1Hz. Knowing the speed of light and the operating frequency, this comes out at about 2.85cm.
For a 1khz doppler shift, the vehicle will have to travel 1000 times the distance (ie 28.5m) With a little bit of maths, 28.5 metres per speed can be shown to be the same as 60m.p.h. This is the doppler shift that the vehicle driver would experience, if he were set up to measure it. Remember though, the doppler module output will be 2kHz, because it is receiving a reflected signal from the vehicle and therefore experiences a second dose of doppler shift.

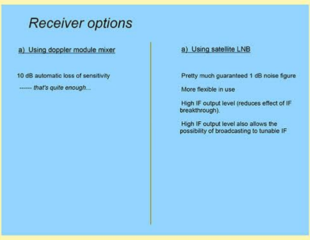
6. Now down to the business of using the doppler module in a communications situation. First consider its use as a transmitter. We will need to modulate it, and it is easiest (and safer for the device) to use Wide Band FM modulation do do this.
The reason for using WBFM over NBFM is quite simple: The oscillator frequency is not particularly stable, either with temperature change or with mechanical shock, the latter being relevent because of the extremely crude way that the unit is put together (a flimsy aluminium lid, which is not soldered down, but rather kept in place by bending its four taps over on the other side of the pcb). Grounding is therefore not particularly well defined, and can occur randomly at any point between the tabs and the pcb ground tracking.
Obviously the wider the FM deviation the better, from this point of view, but it is adequate to use the Band II broadcast deviation convention of +-75kHz peak deviation, since receivers using this standard are readily available for use as the tuneable IF.
FM modulation is achieved by modulating the oscillator supply rail voltage. Only about 10mV rms is required to achieve +-75kHz deviation. The circuit shown could be simplified, but beware doing so. Start with a 5v regulator and make sure the modulator, when flat out (ie clipping) is not able to swing that 5v more than say 100mV. In this way, you won't blow up the FET – hence the 4R7 and 470R resistor values. Ideally, the audio amplifier IC should clip at about +-100kHz deviation, since this will ensure minimal over deviation. Since FM receivers all employ de-emphasis (cutting down the higher frequency modulation components), pre-emphasis is required in the modulator, the 1M 1nF parallel combination on the amplifier input provides this. Not adding the pre-emphasis will result in bassy and woolly audio.





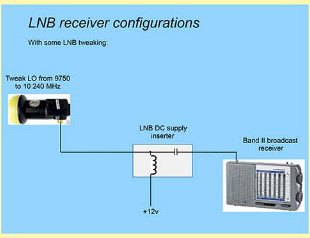
7. Complete audio amplifiers using the TDA2822 chip are available cheaply on ebay for anyone who prefers to buy as much built-up as possible, though the chip itself is a mere 20p from gqrp club sales.

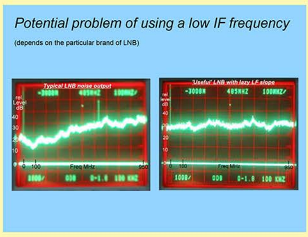
8. Another modulator possibility is available via Amazon and uses the MAX9814 chip. The advantage with this arrangment is that the chip has an automatic gain control circuit that keeps the mic audio level, and therefor deviation level, constant. This might be a useful feature.



9. Whilst the mixer output on the doppler module can be used to feed a tuneable IF, the lack of front-end RF amplifier stages means that the sensitivity will be some 10dB down on what a satellite LNB can provide. This is the equivelent of reducing the 10km range mentioned at the beginning down to 3km. There are further disadvantages too. If you try to get-back that range by using a dish, because the receive and transmit patch antennas are in different positions, the dish will not be pointing to the same place when switching from rx to tx. Additionally, using the doppler module for both tx and rx functions forces the person at the other end of the link to use the same IF frequency, and this limits flexibility. Using a satellite LNB for receive allows complete independence of tx and rx functions, and allows self monitoring of the transmit signal.
Any UK LNB that has dual 9.75/10.6GHz Local Oscillators should be suitable, and these have been the standard for at least 15 years. If you have one of those original Marconi Bluecap LNBs, it's time you threw it in the bin, since its image filter will degrade sensitivity (Explanation: over the years, as the Sky empire has grown, more bandwidth has been required and the current LNBs can be expected to work down at full sensitivity into our amateur allocation).
In the absence of a 22khz tone on the LNB supply rail, the default LNB LO frequency will be 9.750GHz. Thus, with an unmodified unit, the IF output frequency will be 600MHz, assuming that the doppler module frequency had been adjusted to 10.350GHz.
It is possible to tweak the LNB LO frequency, so that a more convenient IF frequency can be used.
The following slides cover these two options.

10. If you are lucky, you will already have a 600MHz WBFM receiver available, so no LNB modification/tweaking will be necessary. This may either be in the form of a scanner receiver or less obviously (as in my case) something like a Yaesu VX-5 hand transceiver that has full receive coverage up to and through 600MHz.
A 12v supply is needed for the LNB, and a DC blocking capacitor should be placed in series with the connection to the receiver, just in case its antenna input presents a DC short to ground. The capacitor value only needs to be 100pF or so. A five turn coil, closewound on a 4mm mandrel will be suffient for feeding in the 12v DC, but this is not criticle. You could decouple the battery end with a 1nF capacitor as 'good practice', but again, it is not that important.





11. If a 600MHz receiver is not available, it is always possible to tweak the LNB LO frequency adjusting screw to change its frequency, thereby changing the IF frequency. Putting the screw further into the casting increases the LO frequency, resulting in a lower IF frequency. Likewise unscrewing the adjuster will decrease the LO frequency to produce a higher IF frequency. In this latter case, there are no complications, but decreasing the IF frequency can generate a problem, as the next slide shows (ie, decreasing IF gain with decreasing IF frequency).
Ignoring the potential gain problem for the moment (it may require selection of a suitable LNB model), the obvious 'new' IF would be the top end of Band II, since there are plenty of analog portable radios about. To avoid strong Band II broadcast breakthrough, it might be well to tweak the coverage of the radio upwards to say 115MHz. There is usually enough adjustment available via the trimmer capacitors built into the polycon tuning capacitor to do this, although this precludes the use of a digital PLL radio.
Another posibility is the use of a multimode 70cm receiver, if it has a WBFM detector setting.
An interesting alternative is the very cheap Poundland FM only receiver. These use a Far Eastern version of the old Philips TDA7000 chip. Frequency coverage is deternined by one tuned circuit – taking turns off the coil readilly allows a new coverage to be obtained to at least 450MHz.
There must be other possibilies waiting to be discovered...

12. In its intended use, a satellite LNB is not expecting IF signals below 950 MHz, and with early models, the IF gain was deliberately sloped downwards below this frequency. Again, a case of good practice.
These days, however, where every penny saved at the design stage is seen to to be important, you never quite know what you will get, as the two pictures above show. These are both current LNB models.
In the case of the RH picture, IF gain appears flat to well below 100MHz. However, the LNB shown on the LH picture has much reduced output at 110MHz and did not perform at full sensitivity at this IF. From what I see with my random stock of LNBs about a half have compromised sensitivity, so model selection is really necessary. As a group, if there is enough interest, a 'good' current model could be sought and a number bought on ebay. The price would be anywhere between £5 - £10.

So, is there sufficient interest out there?!

Bernie