VHF,UHF and SHF TRANSVERTERS

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Topics in Presentation

History of Transverters

Generic design

Band by band analysis:-

What transverters are available

(commercial :- new and used, kits and homemade)

IF transceivers

General

Questions

History

The early use of SSB on the VHF/UHF bands during the 60s-70s (+/-) required a method of translating the HF signals to and from the VHF/UHF bands, and hence transmit and receive converters were developed. The name was shortened to transverter

The signal handling performance of the HF transceivers at the time was not good, and the performance of the transverters was often not good either . The performance of the units together was inadequate, and would show limitations with strong signals on the bands.

During the 70's multimode (or SSB only) transceivers, such as the FT221, TS700, Liner 2, IC202, etc and equivalent 70 cm units appeared on the scene and tended to replace the transverters on the VHF/UHF bands.

As VHF/UHF transceivers increase in frequency, limitations occur in the VCO design and this increases phase noise, which limits the close in performance. (1) Additionally the sensitivity of VHF/UHF transceivers may be less than optimum. (2)

History

These 2 points, with improved performance (?) of HF transceivers, and more recent transverter design have given the opportunity for growth in the VHF/UHF transverter markets.

At 1296 MHz and above, transverters are still the dominant way to appear on the bands as VHF/UHF transceivers sometimes cover 1296 MHz and rarely 2400 MHz. IF band is typically 144 MHz , possibly graduating to higher bands at much higher frequencies.

Transverters have to compete with the multimode/multiband rigs on the market.

Transverters appear more complex; ie have more wires, going to and from unit.

Generic Design of a Transverter

Transverters are comprised of a number of functional modules

- Local Oscillator
- TX Upconverter
- RX Downconverter
- Switching

Local Oscillator (LO)

Based on a Crystal Oscillator typically around the 60 to 100 MHz region .

The crystal operates in an overtone oscillator (the crystal operates on a vibrational harmonic of a fundamental frequency (the fundamental frequency is in the region of 20 MHz). 3rd overtone crystals are ~ 60 MHz and 5th ~ 100 MHz

The output of the oscillator chain provides an output that is normally spaced ~ 28 or 144 MHz, below the RF Input band (sometimes 432 MHz is also used). The Low side LO maintains the correct sideband (ie USB = USB). However when converting from 50 MHz to 144 MHz, the LO is at 94 MHz

Local Oscillator (LO)

LO's for lower VHF bands, typically have a oscillator that is amplified to provide sufficient output for mixing. This also provides isolation so that the changes due to loading is minimised.

LO's for higher bands rely on having the Overtone oscillator multiplied in stages up to the final oscillator frequency.

In the case of a 10224 MHz oscillator this typically means a multiplication ratio of 96 times.

It is important therefore to regulate at least the crystal oscillator and preferably the rest of the oscillator chain as well. Oscillators at frequencies above 1 GHz should have a heater over the crystal to reduce thermal drift.

TX Upconverter

Modern upconverters operate at low level. Some early designs operated as power mixers using 2C39 valves or varactors as mixers

The mixer normally consists of either diode or Bipolar or FET mixers, usually in a balanced configurationto reduce the levels of unwanted products vs a single ended mixer.

The LO is fed into a mixer at a sufficient amplitude to provide good mixing action.

Balanced diode mixers normally have +7 to +10 dBm LO level (5 to 10 mW). Higher frequency diode mixers may operate in a subharmonic mode and maybe driven upto +17 dBm (50 mW). FET mixers typically operate with 1 to 5 volts (pk to pk)LO drive.

TX Upconverter

The IF level from the driver Transceiver is attenuated down to a level to provide linear conversion (Mixer not compressing due to IF Drive) and a low level of unwanted spurious.

For balanced mixers operating at the LO levels above, the IF level should be kept low

For diode mixers, – 6 dBm and below . while for FET and Bipolar mixers it is even less. Some mixers in transverters are driven at 0 dBm (-1 dB compression point), because that is what the mixer specs said. Not a good move as the distortion products generated are high. The products may be **inband** (on channel or harmonics of IF drive) and out of band. (The unwanted products may not be able to be filtered out)

TX Upconverter

Following the mixer is filtering to reduce the level of unwanted signals.

These signals may consist of IF drive, LO drive, harmonics of both IF and LO drive, Mixing products of IF and LO drive together, and Mixing products of harmonics of IF and LO drive together. **Normally the LO + IF product is used**

The filtering may consist of tunable circuits, such as helical resonators, stripline or wire inductors tuned with capacitive trimmers, tunable inductors, pipecap cavities or fixed tuned circuits such as fixed stripline inductors, such as hairpin (the shape).

The filtering is normally done in multiple stages, interrupted by class A amplifier stage (s) to increase the RF level. This also minimises the interaction between the filter stages.

The class A amplifier stages are normally up to 10 to 100 mW, which then feed a seperate amplifier to give between 1 and 20 watts. This module may be discrete transistors, or more recently in power modules.

RX Downconverter

A RX downonverter basically takes the incoming signal and amplifies it in the RF stage(s). It is then sent to the mixer, together with the LO, before apppearing at the IF frequency.

There is filtering before the mixer, (and to a lesser extent before the RF stage) so that the level of unwanted signals are reduced. The filtering technology is similar to that in TX converters.

The RX amplifier(s) may be multistage in some designs and be a combination of devices.

It is important that the overall RX gain should only be sufficient to just override the IF transceiver noise by 6 to 10 dB. Typically 20 - 25 dB overall in 28 MHz designs and 15 to 20 dB with a 144 MHz IF.

This results in reasonable signal handling and adequate noise figure. Some designs have gains in 35 to 40 dB for 28 MHz IF and 40 dB + for 144 MHz IF (Excessive)

RX Downconverter

The mixer may be common to the both the RX and TX converter (seems sensible) and this may also result in some of the RF filtering be common as well. When the mixer is common to TX/RX it is most often a double balanced diode mixer, due to its bilateral ability <-->

Some early (and still available) RX converter designs using seperate mixers have a single ended mixer, (single device such as a Bipolar, JFET or Mosfet) The oscillator is not cancelled out in these designs and may appear at the IF port at levels of the order of 10's to 100's of mV

Switching

The switching of TX RX paths involves the switching of DC supplies and also RF paths.

This is preferably done under a control signal appearing from the driver transceiver.

This may be a PTT signal (+/-) or a TX/RX voltage appearing at the antenna port of the transceiver.

It is also preferable that some sequencing is used, but is often not the case except in higher power and microwave setups. (Relay isolation during switching can be an issue.)

The DC supplies to the RX and TX portions of the transverter may be switched via relays or by transistors/FETs.

Internally some RF switching, if necessary, may be done by switching diodes, either conventional or PIN. In some cases passive combiners/ hybrids are used and the increased losses are absorbed in the design.

The antenna switching is normally done by good quality relays (coaxial ones at higher frequencies). However on some units PIN diodes are used. (Microwave modules Ltd)

50 MHz (6 metre) TRANSVERTERS

General Notes

Most transverters use 28 MHz,144 Mhz or even 14 MHz
Extra filtering is required to reduce Intermod and harmonic products

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	50 -28	New	Kit	Excellent dynamic range.Versatile design
Ten-Tec	1208	New	Kit	Cost effective 14 MHz IF
Ten-Tec	1209	New	Kit	Cost effective 144 MHz IF
Mutek	TVVF50c	Old/new	Built	144 MHz IF. New owner of Mutek may continue production Excellent dynamic range. 2 crystals to cover 4 MHz band.
Mutek	TVVF50a	Old/new	Built	28 MHz IF. New owner of Mutek may continue production Excellent dynamic range. 2 crystals to cover 4 MHz band
SSB Electronic	LT6 (?)			Old but good design
MMT50-28		Old	Built	MMT is out of business, but units appear on EBAY,etc Older versions (black box) limited performance. Single FET RX mixer Later versions in silver box somewhat better
MMT50-144		Old	Built	MMT is out of business, but units appear on EBAY,etc Older versions (black box) limited performance. Single FET RX mixer Later versions in silver box somewhat better
Yaesu	FTV650	Old!	Built	Valve PA
	FT107,707	Old	Built	MC1496 TX mixer Single FET RX mixer
	FTV-1000	New	Built	$$$
Elecraft	XV50	New	Kit	2stages before RX filtering. Versatile design

144 MHz (2 metre) TRANSVERTERS

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	144 -28	New	Kit	Excellent dynamic range.Versatile design
Ten-Tec	1210	New	Kit	Cost effective 28 MHz IF
Mutek	TVVF144a	Old/new	Built	28 MHz IF. New owner of Mutek may continue production
				Excellent dynamic range. 2 crystals to cover 4 MHz band.
SSB Electronics	LT2			Old but good design
DB6NT/Kuhne	TR144	New	Built	New design. $$$
	MMT144-28	Old	Built	MMT is out of business, but units appear on EBAY,etc
				Older versions (black box) limited performance. Single FET RX mixer
				Later versions in silver box somewhat better
Yaesu	FTV250	Old!	Built	Valve PA
	FT107,707	Old	Built	MC1496 TX mixer Single FET RX mixer
Elecraft	XV144	New	Kit	2 amplifier stages before main RX filtering. Versatile design

622 (50cm)TRANSVERTERS

General Notes
Most transverters use 144 MHz or may even use 432 MHz

Transverters

Manufacturer	Model	Old/New	Notes
Homemade			Use 144 or 432 MHz IF. No commercial unit available. Discrete PA

925 MHz (33cm) TRANSVERTERS

General Notes
Most transverters use 144 MHz or may even use 432 MHz
Extra filtering is required to reduce Intermod and harmonic products

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	903 -144	New	Kit	Excellent dynamic range.Versatile design. Needs retuning
DEM	903 -144	Old	Kit	Hairpin design. MMICs. Hairpins need trimming
SSB Electronics	LT33	Old	Built	For 903 Mhz. Needs retuning

432 MHz (70 cm) TRANSVERTERS

General Notes

Most transverters use 28 MHz and some may even convert to 144 MHz
Extra filtering is required to reduce Intermod and harmonic products

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	432 -28	New	Kit	Excellent dynamic range.Versatile design
SSB Electronic	LT432	Old	Built	Old but good design
DB6NT/Kuhne	Tr432	New	Built	$$$
MMT432-28		Old	Built	MMT is out of business, but units appear on EBAY,etc Older versions (black box) limited performance. Single FET RX mixer Later versions in silver box somewhat better
MMT432-144		Old	Built	MMT is out of business, but units appear on EBAY,etc Older versions (black box) limited performance. Single FET RX mixer Later versions in silver box somewhat better
	FT107,707	Old	Built	MC1496 TX mixer Single FET RX mixer
Minikits	432 -28	New	Kit	Uses MMIC's and helical filters. Low power add PA module
G3WDG	432 -28	New	Kit	Uses MMIC's, FETS and helical filters. Low power add PA module

1296 MHz (23cm) TRANSVERTERS

General Notes

Most transverters use 144 MHz

Extra filtering is required to reduce Intermod and harmonic products

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	1296 to 144	New	Kit	Excellent dynamic range.Versatile design
SSB Electronic	LT23S	Old	Built	Bipolar TX mixer and GaAsfet RX amplifiers and mixer
DB6NT/Kuhne	MK13G	New	Kit/Built	Old and new Variants
	TR1296H	New	Built	20 watt.28 MHz IF (144?).High Performance. Price $$$
Microwave Modules Ltd	MMT1296 144	Old	Built	MMT is out of business, but units appear on VKHAM,EBAY,etc Early and late versions (1.2 and 2 watts) limited performance. Bipolar and GaAsfet RX amplifiers
Minikits (VK)	1296 to 144	New	Kit	100 mW MMIC design, helical filters.+ 30 watt amp, good price overall
RSGB G3WDG	1296 to 144		Kit	Low power a few milliwatts

2424 MHz (13cm) TRANSVERTERS

General Notes

Most transverters use 144 MHz

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	2304 to 144	New	Kit	Uses hairpin loops and mixer optimised for 2304 Mhz. Requires tuning
SSB Electronic	LT13(?)	Old	Built	Similar to 1296 version
DB6NT/Kuhne	MK23G	New	Kit/Built	Old and new Variants
	TR2320H	New	Built	15 watts.144 MHz IF.High performance.Price $$$
Minikits (VK)	1296 to 144	New	Kit	100 mW MMIC design, helical filters Add on 30 watt amp, good price overall
RSGB G3WDG	1296 to 144		Kit	Low power a few milliwatts. Needs extra TX filter

3400 MHz (9 cm) TRANSVERTERS

General Notes

Most transverters use 144 MHz IF, however 432 MHz may be used

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	3400 to 144	New	Kit	Pipecaps and MMICs. Hi and Low power option
DB6NT/Kuhne		New	Kit/Built	Pipecap design
ARRL	W1VT		PCB artwk	Hairpins and MMIC's

5760 MHz (6 cm) TRANSVERTERS

General Notes

Most transverters use 144 MHz IF, however 432 MHz may be used

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	5760/144	New	Kit	Pipecaps and MMIC's. Hi and Low power option
Old DEM	5760/1296	Old		Used hairpins and MMICs. 1296
DB6NT/Kuhne		New	Kit/Built	Pipecap design

10 GHz (3cm) TRANSVERTERS

General Notes

Most transverters use 144 Mhz, however 432 or 1296 MHz may be used
Extra filtering is required to reduce Intermod and harmonic products

Transverters

Manufacturer	Model	Old/New	Notes	
DEM	10368/144	New	Kit	Excellent dynamic Ghz design
SSB Electronics		Old		Early Gasfet design
DB6NT/Kuhne		New	Kit/Built	
RSGB G3WDG	10369/144		Kit	Seperate TX and RX converter. Lo is G4DDK004 or variant TX mixer is single GaAsfet. TX power 50 to 100 mW. Amplifiers 300mw to 1 watt Rx mixeris dual diode. Availability?
Surplus	White box NZ	MACOM		Uses surplus units ?

24 Ghz (1.5 cm) TRANSVERTERS

Most transverters use 144 Mhz, however 432 or 1296 MHz may be used
From 24 GHz upwards DB6NT/ Kuhne produces kits and prebuilt units that cover bands to several 100's of Ghz .
There are a number of 24 GHz power amplifiers that can produce power from 500mW to 2 watts. EBAY and DB6NT.
DB6NT also manufactures a range of 24 Ghz submodules. Low noise preamps and low medium power amplifiers

IF Transceivers for driving transverters

Earlier designs of HF and some VHF Transceivers rely on single conversion and have SSB filters close to the 1st mixer.

Later designs deployed crystal roofing filters used as FM filters and these were also used in noise blanker circuitry.

Some HF designs also upconverted so that the 1st IF was above the RF frequencies and then remixed to a lower IF such as 9 MHz, 10.7 MHz or 455 kHz. There was a trend to add further amplification in these roofing filter stages (before the SSB filter)

FACT:-Any amplification between the roofing filter and the SSB filter degrades the Blocking and Intermodulation performance of signals close to the wanted frequency.

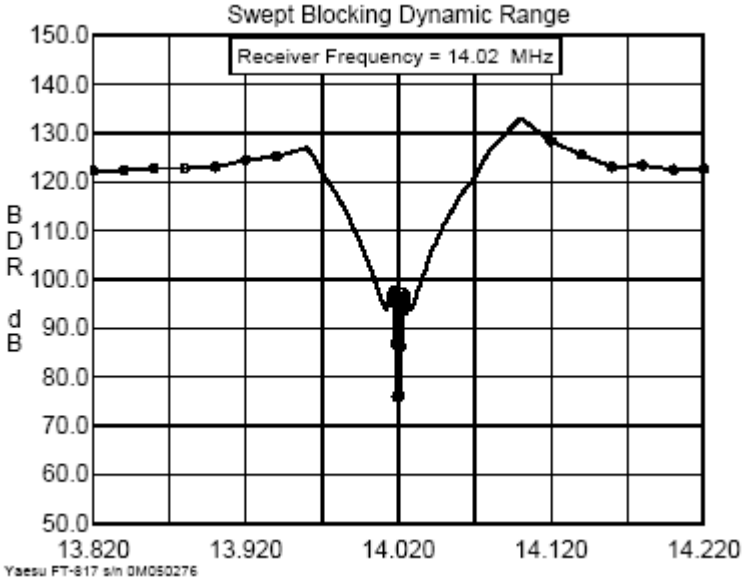
Later transceivers such as the FT817 and Ft1000MP show this degradation

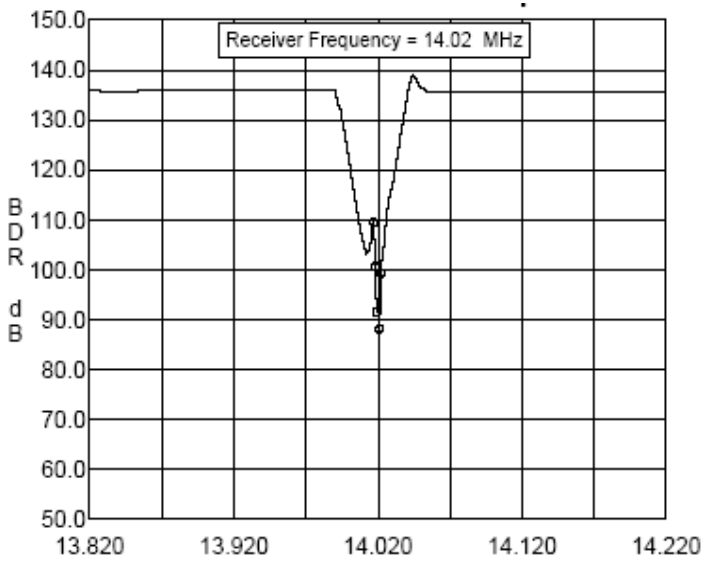
Fortunately there is trend to reverse this by having the SSB filter early after the 1st mixer. A good example of this is the Elecraft K2

Other early HF transceivers, using single conversion, should perform well.

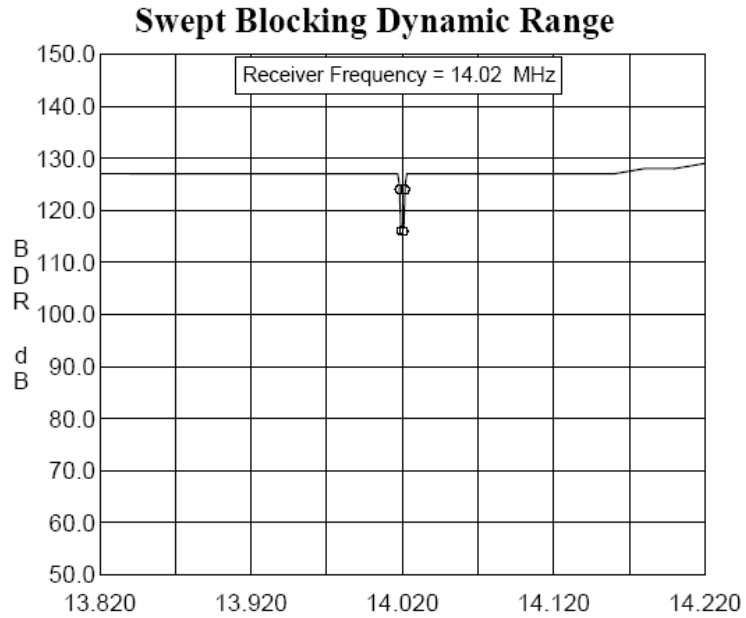
Early single VHF Transceivers such as the crystal controlled IC202 perform well in SSB/CW service. There are a multitude of VHF Multimode transeivers which could be used as IF transceivers, on the higher microwave bands.

Look at the parameters such as signal handling, phase noise and other important criteria carefully. This applies to both HF and VHF transceivers used for IF transceivers

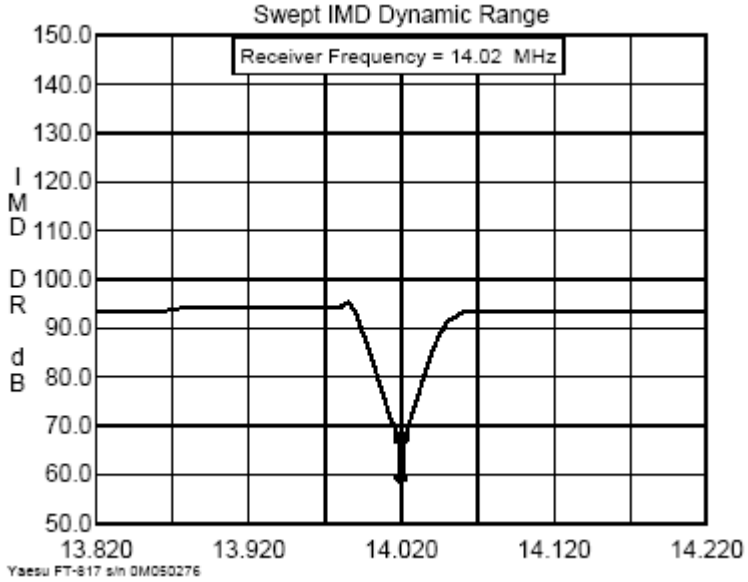


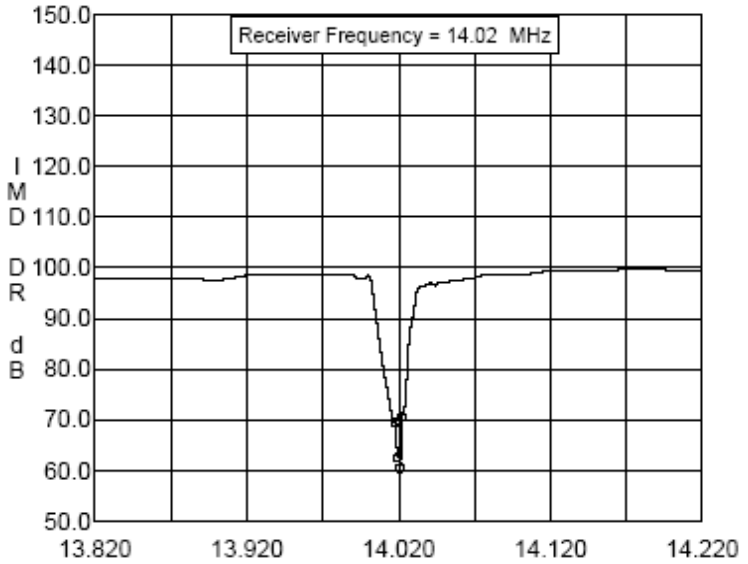


Yaesu FT-1000MP Mk5
Blocking Test



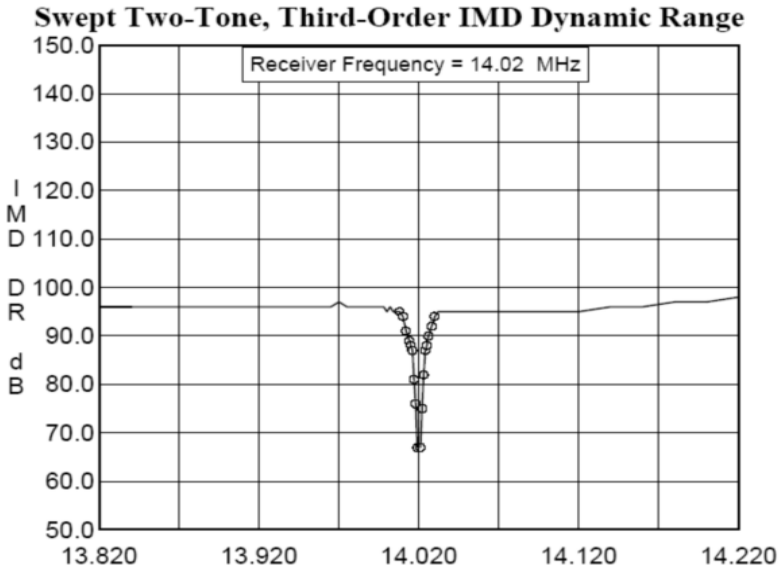
Elecraft K2





Yaesu FT-1000MP Mk5

Two tone IMD test



Elecraft K2

Sources of transverter circuits

The VHF/UHF DX Book (RSGB)

Various issues of DUBUS magazine (DB6NT)

Reviews of transverters in

Buyers Guide to Amateur radio (RSGB) by G3OSS (out of print)

ARRL website (members only)

Useful websites

www.downeastmicrowave.com, www.db6nt.com, www.minikits.com.au

For those with access to facilities, such as club test equipment (or otherwise), then this may give the oppurtunity to homebrew one's own transverter, built a kit, or modify ex- commercial equipment.

The Waikato VHF Group (especially Tom Bevan, ZL1THG) has built a number of 1296, 2424 and 3399 MHz transverters, that are on loan to a number of individuals around the country, especially in less populated areas. We asked that a Waikato VHF Group membership be paid, that ofset a small portion of the cost. (less than the price of the crystal).

This has resulted in increased microwave interest and activity,

Increasing club membership,

Steve ZL1TPH has loaned out his personal transverters, also increasing activity.

----------QUESTIONS----------