INTERNATIONAL AMATEUR RADIO UNION
REGION 3
SIXTEENTH REGIONAL CONFERENCE

12 – 16 October 2015 Bali, Indonesia

Document No. 15/XVI/043
Agenda Item: 12.3

Digital Modes Development in New Zealand

A paper from the New Zealand Association of Radio Transmitters Incorporated (NZART)

Murray Greenman ZL1BPU

Introduction

This paper reports on current digital mode practice, and on the development of new digital modes and techniques in New Zealand over the last three years. Digital radio techniques offer new levels of performance in Amateur Radio, and provide solutions to significant technical challenges. One of these has been the provision of reliable text communication under NVIS propagation conditions, until now a serious barrier to effective emergency communication in remote locations.

Recent developments have seen the line between transceiver hardware and computer software blurred by the entry of significant digital signal processing. This combination of new technology provides an attractive way of recruiting new people (with a computer interest) to the hobby, and retaining the attention of technically capable amateurs, through interesting new projects.

In the last decade the trend in digital mode development has been towards more complex modulation, accompanied by ever more complex error correction coding, in attempts to solve the technical problems. However, one local team has reversed this trend, and has achieved high performance with very simple but carefully chosen techniques, with attendant advantages of simplicity of use and slick operation.

New Zealand is uniquely placed to develop new digital modes, with the advantages of geographic isolation, and the benign and encouraging attitude of the regulatory authority, the Ministry of Economic Development, to the development and testing of new modes.

It could be argued that there has been as much new development in New Zealand in the last few years as there has been anywhere in the world.

Popular Digital Modes.

Many Amateurs are finally beginning to realize that the choice of the mode to use under given conditions (band, interference and nature of propagation) is not trivial, and the traditional choices for DX of **RTTY** or **PSK31** are not often the most appropriate solution.

PSK31 continues to maintain high popularity in this part of the world, as everywhere. It is well suited to short-hop DX, but not so good for long path operation, where **MFSK16** is more suited. Nor is it suited to lower band NVIS operation, where MFSK modes such as **DominoEX** and **EXChat** (a chat-oriented version of DominoEX) have gained limited popularity. DominoEX in particular has been found to be excellent for maintaining contact with stations on Pacific Islands and cruising yachts.

However, by far the biggest recent impact globally has been made by the release this year of another new mode, **FSQ,** developed in New Zealand. This new mode will be covered separately later.

There has been a modest uptake of Digital Voice, principally **D-Star** technology, in New Zealand, with VHF and UHF repeaters and gateways to the Internet serving most cities. Personal gateways have also proved to be very popular, since they allow users instant access, and greater freedom to choose the destination. At present only one of the major manufacturers of Amateur equipment is offering D-Star equipped radios. The technology is not really realistic for home design other than using pre-packaged codec devices, such as are used for the personal gateways.

Limited trials have been made in New Zealand of **FreeDV**, an open-source application offering Digital Voice with a software codec. The system utilizes a 16-QPSK modem, and it appears to work quite well under some limited local conditions, but is frequently unreliable. A major advantage of the technique is that no specialized devices are required, apart from two sound cards. Of course operation is also tied to a computer, which can be inconvenient.

Software Defined Radio

SDR has made quite an impact among the more progressive Amateurs. Perhaps the most popular application, and also the simplest and cheapest entry point, is the inexpensive TV dongle for VHF reception, or with up-converters for HF reception. There is truly excellent software available for these devices, which allows operation on all modes and frequencies from 10 kHz to 1500 MHz. These devices can even be used in a highly portable manner with tablet computers. While superficially very simple, the performance of these devices is truly remarkable if used with care.

The author has adapted one of the popular TV dongles to operate both VHF/UHF and LF/MF/HF without an up-converter (using direct sampling and software switching), and again the performance is remarkable. In addition, the

stability using this approach is significantly better than is typical with an up-converter.

Commercial high-performance software-defined receivers are now widely available, although still relatively expensive. A small number of local Amateurs have now purchased fully software defined HF transceivers, which are available from several sources, but again they are still unattractively priced.

New Developments – EXChat

EXChat is a variation of DominoEX (utilizes exactly the same modem and alphabet coding), but has been redesigned to provide 'chat' mode operation. Traditional text digital modes follow a 'rag-chew' model similar to voice operation, where one operator holds forth for several minutes (transmitting while typing), while listening stations patiently read the incoming text or perhaps type ahead of their own subsequent transmission.

'Chat' mode operation is more like sending internet chat or phone text messages – you type a short sentence and press Enter – so the conversation is more immediate, and much more approaches a natural face-to-face conversation. Chat mode leads to better channel utilization and better information interchange. EXChat, developed in New Zealand by Con Wassilieff ZL2AFP, was the first mode to offer this capability.

New Developments – WSQ

LF and MF Amateur operation is constrained by the financial and practical limitations imposed by operation in suburbia. In particular, transmitting antennas for the 2200m and 630m bands that will fit in an urban lot have extremely low efficiency, typically less than 1%. In consequence, received signals are often very weak. Hence there is strong interest, among LF and MF operators, in digital modes capable of extreme sensitivity. To date the best is WSPR, developed by Joe Taylor K1JT, which is capable of reception at –30dB SNR in 2.4kHz bandwidth. Using WSPR, the author has been received in Western Australia (5200km) on 473 kHz. However, as with similar weak signal modes, WSPR is a one-way mode, extremely slow, and not capable of real QSO interchange between stations since it only sends callsign, power level and location.

In order to address this situation, Con ZL2AFP, with the help of the author, developed a Weak Signal QSO mode, **WSQ**, which is capable of reception at –27dB SNR, and yet is capable of sending free-form text at 5 to 7 words per minute. WSQ uses 33-FSK, and operates at 0.512 baud in a bandwidth of 66 Hz. The text speed is slow, but adequate for a QSO, and is achieved despite the very slow symbol rate, through the use of a cleverly designed alphabet. The alphabet can send all lower-case letters in just one symbol, and all others in just two.

Although not widely used yet, WSQ has been demonstrated to provide good DX contacts (such as ZL to VK on 630m and trans-Atlantic on 2200m). It has been demonstrated that if stations can achieve a report of –25dB on WSPR, a two-way FSQ contact will be viable.

New Developments – FSQ

Based on what was learned through the development of WSQ and EXChat, the ZL2AFP/ZL1BPU team more recently developed a higher-speed modem based on the alphabet and coding of WSQ, but tailored specifically for NVIS propagation, i.e. 2 – 10 MHz, daytime on the higher bands, night on the lower bands. These are exactly the conditions met by portable and emergency stations in remote locations and those where no reliance can be placed on infrastructure.

FSQ is a chat mode, which utilizes an offset Incremental Frequency Keying algorithm (IFK+) that minimizes inter-symbol interference, avoids synchronism difficulty and provides complete independence from signal drift and miss-tuning.

FSQ was developed specifically for Emergency Communications applications, and yet has been given features that make it very popular for general use. FSQ is designed for fixed-channel operation, rather than the usual Amateur practice of ‘tuning around to find someone to talk to’. With fixed channel operation comes the expectation that the fellow you want to pass a message to will probably be on the same channel.

FSQ uses no error correction, and yet, by design, has a low error rate. The design provides a typing speed of between 40 and 60 works per minute, with error rates under most conditions that are lower than the typist’s keyboard error rate. With no error correction, there are no delays, making for very effective chat mode operation. You simply type a sentence, and press Enter.

A unique feature of FSQ is that it does not require symbol synchronization for reception. The receiving algorithm uses a voting process to determine when a symbol has finished and another started. The significance of this is that the receiver will correctly decode transmissions over a speed range of 3:1 without adjustment, and will as a result easily handle significant reception timing changes, which occur due to differing ionospheric paths. This is a major step forward in reception performance.

This timing independence and tuning independence, allied to low susceptibility to inter-symbol interference (a result of using IFK+), means that FSQ is very robust, and has very low latency. With these properties and Emergency Communications in mind, the developers added a very comprehensive Selective Calling and automatic response system to FSQ. Such a command structure is only practical when reception is highly reliable. When this FSQCall Directed mode is enabled, participating operators can send text, messages,

files, images and commands to one or more specific stations (selected by callsign) or to all available stations.

Utilizing a very simple ‘Sounding’ technique, each station in Selective Calling mode also builds up a list of available stations. Operators can also ‘ping’ other stations to check that communication is viable. All reception is also logged.

Unlike commercial selective calling systems, which require pre-registration and training of operators, prior registration and setup of specialized equipment to registered addresses and frequencies, FSQCall operates using operator callsigns as addresses, and utilizes standard Amateur equipment, so is a completely *ad hoc* system, an important factor in emergency communications. In addition to the usual mesh network arrangements, FSQCall is uniquely capable of automatic message relay via third party stations.

Calling channels for FSQ have been set up in IARU Regions 1, 2 and 3, on the 80m, 40m and 30m bands. Amateurs in the USA have a passion for message passing and relaying, and FSQ activity is now widespread there, especially on 30m. There are already some 50 or more operators capable of FSQ operation in New Zealand, with perhaps 10 – 20 regulars on 40m in the afternoon and on 80m at night. Transmitting short message files, photographs and web camera images has proved to be especially popular.

Various FSQ-related tools have been provided, including a monitoring tool, which displays station signal strengths *versus* time of day; a formatted message utility, which will allow formal radiograms to be sent very efficiently; and a specialized encryption/decryption tool to be used for efficiently passing sensitive messages during search and rescue or emergency deployments.

Micro-Controller Applications

The last year or two have seen a marked increase in the use of ‘smart’ applications at Amateur stations. The advent of simple embedded Linux devices, such as recycled ADSL modems and the Raspberry Pi units, and other embedded controllers such as the Arduino and the ESPN8266, have made possible a host of new applications – network-controlled and WIFI frequency synthesizers, APRS gateways, intelligent crystal ovens and remote-managed experimental propagation transmission controllers. This will be an increasing trend over the next few years.

We are also now beginning to see quite advanced control applications based on inexpensive Android and Windows tablets and mini-PC dongle computers, which users can readily program.

Contact Person

The contact person within NZART for ”Digital Modes” is Murray Greenman CSc, ZL1BPU. Email contact is available via zl1bpu@nzart.org.nz .

Recommendations

That:

1. Member Societies note that digital modes continue to increase in popularity in Region 3, and that New Zealand continues to be at the forefront of Digital Mode development.

2. The digital portions of the Amateur bands continue to be plagued, however, with unnecessary interference. Societies are requested to publicise the development of digital modes and to educate amateurs not to interfere with digital transmissions of amateur origin.

3. Digital mode operators should note that while PSK31 continues to be widely used, newer modes with better performance in specific areas could be preferable. In particular, Amateurs should consider MFSK16, DominoEX and FSQ.

4. Members should note that experiments with advanced digital modulation techniques continue, and Software Defined Radio is now an established technique, both for commercial and home-brew equipment.

_____