VARA HF Modem Specification

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Jose Alberto Nieto Ros, EA5HVK

1.0 Overview:

VARA HF Modem is a propietary system developed by Jose Alberto Nieto Ros EA5HVK and can be used under shareware license.

2.0 Project Target Objectives:

2.1 VARA is a a half-duplex ARQ system designed to have maximum efficiency over HF channels, fully compatible with all HF path conditions.

2.2 Bandwidth: VARA is designed for operation within a SSB bandwith of 2.4 Khz.

2.3 Speed: VARA uses a fast adaptive 11 data levels in order to maximize the Net Data rate according channel conditions. Net Data rate covers a wide speed range, from 60 to 7536 bps.

2.4 Peak-to-average power ratio (PAPR): VARA has a PAPR of 9dB in DATA blocks, and this value is the same for all the speed levels. This aspect is very important in Gateways stations to avoid power variations between levels and allows a precise control of the power. In the case of ACK burst, the PAPR is 6 dB.

2.5 Compliance with US FCC Symbol rate rule: The maximum symbol rate on any carrier shall be 300 baud or less. VARA uses 42 bps in DATA and ACK blocks. This is in conformance to the current US FCC rules.

2.6 Strong Resistance to Multipath propagation: VARA is based in the OFDM modulation with a cyclic prefix of 3 ms, and it uses advanced error correction techniques (Turbo Codification).

The advantages of OFDM modulation are:

1) Makes efficient use of the spectrum by allowing overlap
2) By dividing the channel into narrowband flat fading subchannels, OFDM is more resistant to frequency selective fading than single carrier systems are.
3) Eliminates ISI and IFI through use of a cyclic prefix.
4) Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.
5) Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems. (VARA Levels 9-11)
6) It is possible to use maximum likelihood decoding with reasonable complexity.
7) OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.
8) Is less sensitive to sample timing offsets than single carrier systems are.
9) Provides good protection against cochannel interference and impulsive parasitic noise.

The disadvantages of OFDM modulation are:

1) The OFDM signal has a noise like amplitude with a very large dynamic range, therefore it requires RF power amplifiers with a high peak to average power ratio.
2) It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT.

2.7 Implementation: VARA is compatible with Windows S.O. Communication with others softwares is done using the Telnet protocol.

2.8 Operating Modes and Radios: VARA is designed specifically for any HF SSB Radio, including SDRs.

2.9 Automatic Timing Setup: The protocol insures automatic timing adjustment for near optimum throughput. Timing will be different depending of distance, and processing time. Timing guarantees 100 ms for the PTT switching.

3.0 Equipment Compatibility:

3.1 Frequency accuracy. The protocol shall accept a connection request where the Client and server frequencies are offset by up to 50 Hz .

3.2 Frequency stability. The short term frequency stability of the transmitter and receiver shall be less than 0.5 Hz/second for SSB operation.

3.3 Sound Card Compatibility: VARA is compatible with any 16 bits PC soundcard that support 48000 Hz sampling rate.

3.4 Software Defined Radios. VARA protocol support the latency typical of any SDR type Radios.

3.5 Keying modes. VARA includes three methods for the PTT keying: CAT Command control, COM control (using RTS or DTR levels), and conventional VOX control. The automatic timing mechanism will handle up to 100 ms delay for the PTT switching.

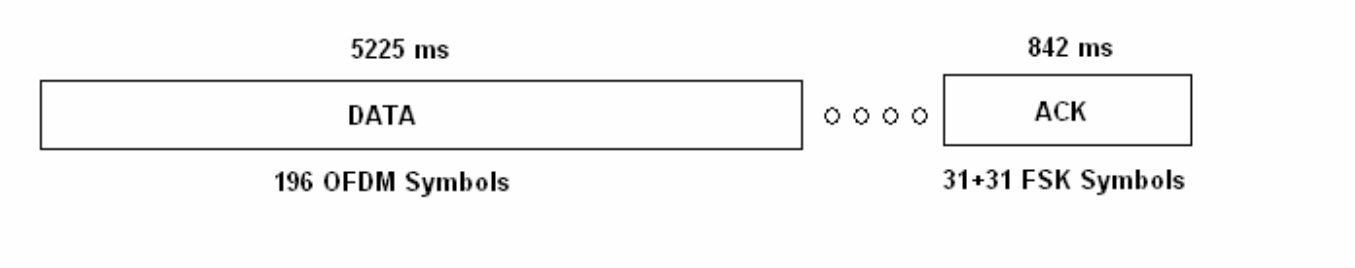
3.6 Host Interface. VARA uses a TCP link to connect with others applications.

4.0 Operating Mode:

4.1 VARA operates in an ARQ (**A**utomatic **R**etry re**Q**uest) mode where *TWO* stations are connected. The stations will operate ARQ where each data frame from the Information Sending station (ISS) is acknowledged by the Information Receiving Station (IRS). In a normal forwarding session the rolls of IRS and ISS will be exchanged several times. With the ACK transmissions the ISS know when repeat the frame, do a break or change the mode.

5.0 Frame Types :

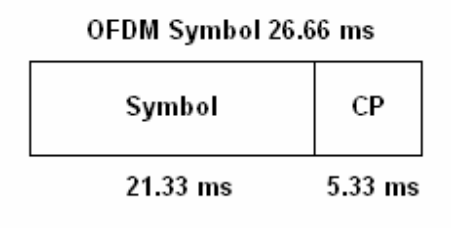
There are two Frame types in VARA: DATA Frames and ACK Frames.



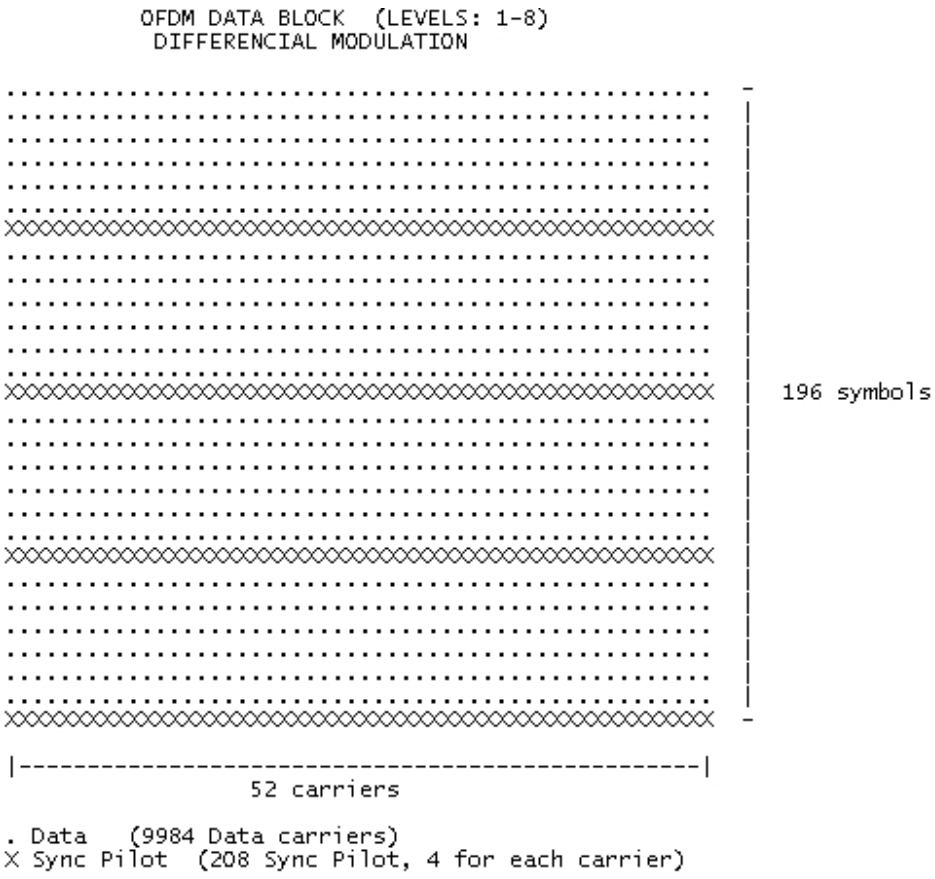
A DATA Frame consists of a block of 196 OFDM Symbols with a duration of 5225 ms.
An ACK Frame consists of a block of 2x31 FSK Symbols with a duration of 842 ms.

5.1 Data Frames.

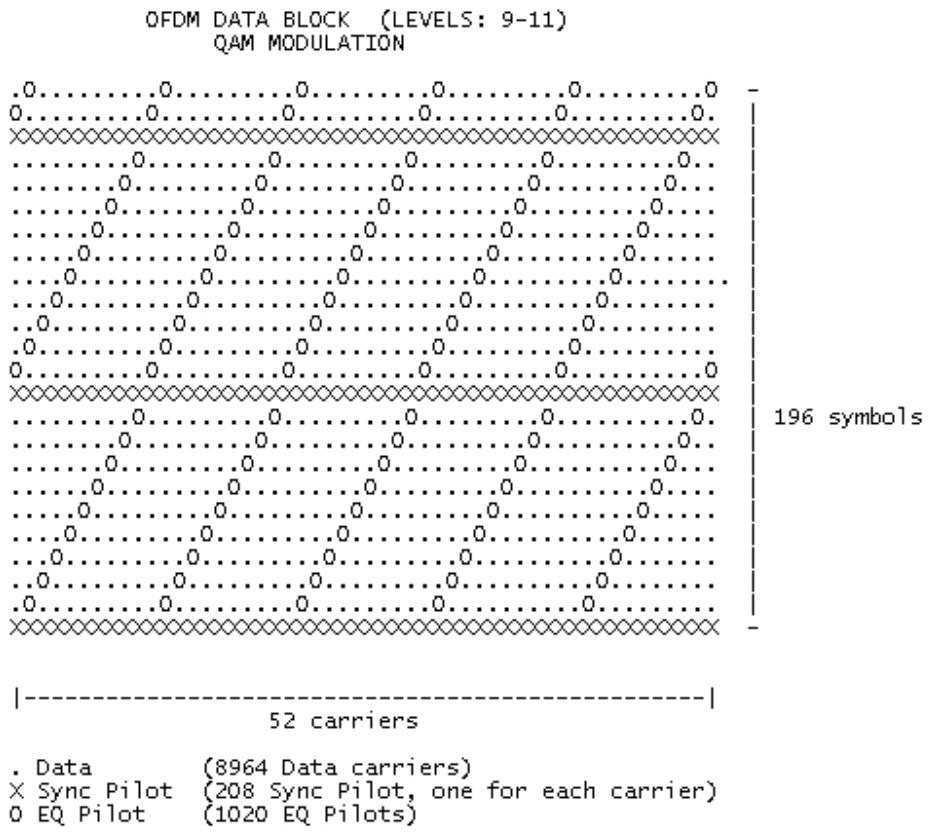
The OFDM Symbol has a duration of 24 ms (42 symbol rate), of which 2.6 ms are the Cyclic Prefix and 21.33 ms are the FFT block.



The OFDM Symbol has 52 carriers with differential PSK modulation (Levels 1-8) and QAM Modulation (Levels 9-11).



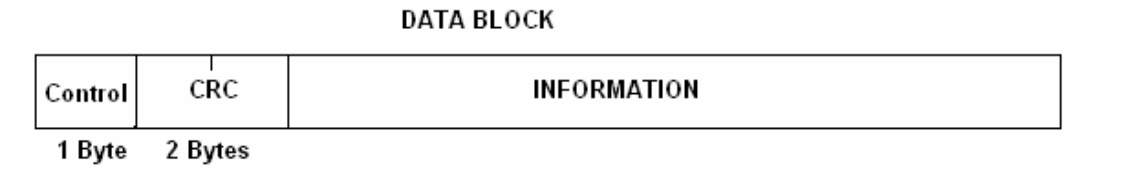
208 Sync Pilot (4 for each carrier) are used for time and frequency synchronization and are distributed in 4 rows along the DATA Frame.
9984 Data carriers are used for the Payload data.



Levels 9-11 use QAM Modulation where equalization is necessary. The protocol include, in addition to the 208 Sync pilots, 1020 EQ Pilots for the equalization process.
The payload in this case 8964 Data carriers.

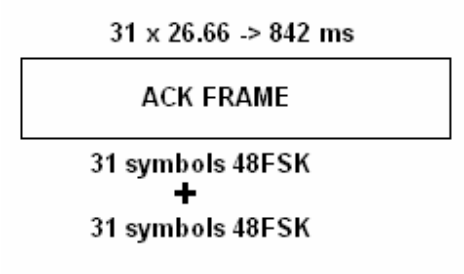
Turbo codification is used for the Forward Error Correction with different redundancy levels to give 11 speed Levels with different Net Data Rates. This closer to VARA to the Shannon Limit.

Level	Symbol Rate	Carriers	Mod.	Bytes / Packet	Net Data Rate	User Data Rate
1	42	52	BPSK	20	60	50
2	42	52	BPSK	32	126	105
3	42	52	BPSK	71	260	217
4	42	52	BPSK	150	529	441
5	42	52	BPSK	308	1070	892
6	42	52	BPSK	626	2143	1786
7	42	52	4PSK	1257	3214	2641
8	42	52	8PSK	1887	4287	3511
9	42	52	8PSK	2951	5024	4115
10	42	52	16QAM	3690	6281	4972
11	42	52	32QAM	4429	7536	5802



The Data Block includes 1 byte for the Control (changeover), and 2 bytes CRC16.

5.2 ACK Frames.



The ACK Frame is based in two parallel FSK modulations of 48 tones and 31 symbols length. Total there are 62 FSK symbols in the ACK frame. Each symbol has 26.66 ms of duration and the Symbol rate is 37.5.

The two modulations running in parallel guarantees un factor PAPR of 6 dB. Thus, with a typical HF Rig of 100 Watts peak, we have 50 Watts rms for the ACK burst (every 6 seconds), and 25 watts rms for the Data block. These power levels are supported for the most HF transceivers without damage in long transmissions.

There are 8 types of ACK Frames:

START: Used to wake up the Gateway station
ACK1: DATA BLOCK received.
ACK2: DATA BLOCK received + up speed.
ACK3: DATA BLOCK received + down speed.
NACK: DATA BLOCK failed
BREAK: changeover
REQ: ACK failed
QRT: end of the session

For each session, the ACK codes are different to avoid false commands when 2 stations are using in the same dial.