Input paper: [[1]](#footnote-1) ENAV21-11.18

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **□** ENG **□** PAP **x**  Input

**x**  ENAV **□** VTS **□** Information

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Technical Domain / Task Number 2 …………………………………

Working Group WG3

Author(s) / Submitter(s) Korean Register of Shipping

Symbol Transmission in Ramp-up period for Receiver AGC settling

# SUMMARY

This proposal is a document prepared to suggest the change of packet structure to perform AGC (Automatic Gain Control) function by analysing the packet detection performance through simulation test based on the packet shown in the standards, and to examine the AGC effect on the received signal and the packet structure of the VDES physical layer.

Based on the result of simulation analysis an additional symbol for the AGC is required, which as a method to acquire additional symbol within the scope of recommendation, we propose valid symbol transmission in the ramp-up period, and a symbol pattern to be transmitted in the ramp-up period through a similar standards analysis.

## Purpose of the document

This proposal is to suggest an efficient scheme, within the scope of recommendation, for the performance of AGC function in order to improve performance of frequency synchronization, timing synchronization and packet detection, and to review function of the appropriate receiver for physical-layer packet structure of the ITU-R M.2092 recommendation.

## Related documents

* Recommendation ITU-R M.2092-0+ (06/2017)

# Background

In the VDES system, ship station and base station modems support TDMA-based multiple access in accordance with ITU-R M.2092 [1] standards, and the required signal is burst-structured.

The burst signal of the VDES system is called 'packet' and its structure is shown in the following figure 1.

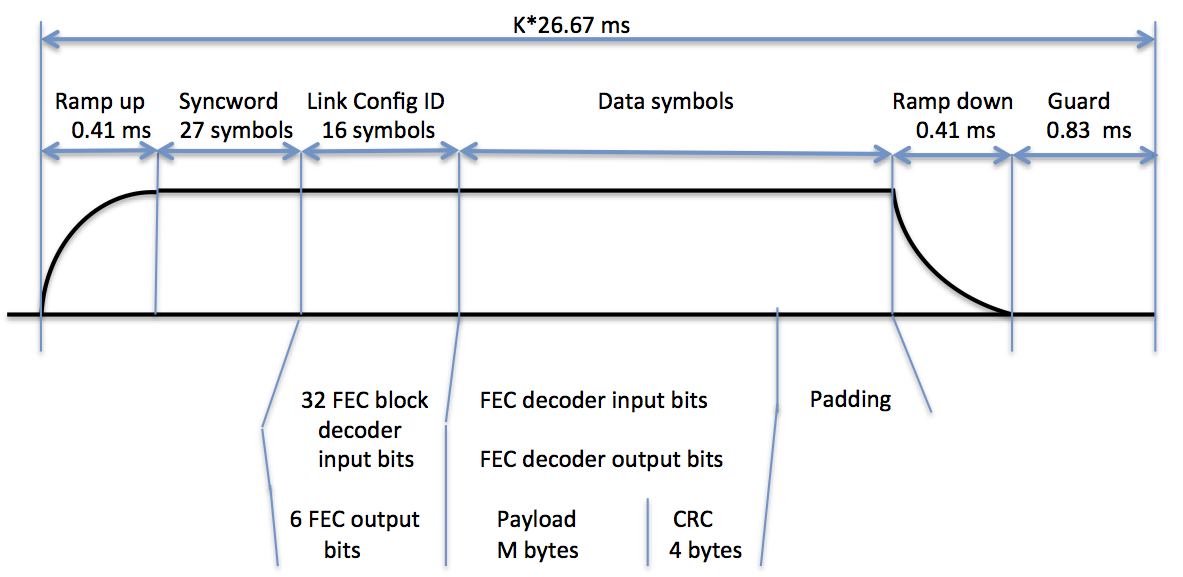


Figure . ASM-TER and VDE-TER General Packet Format

A packet of the VDES system consists of Ramp-up period, Syncword symbols, Link Config ID symbols, Data symbols, Ramp-down period and guard period.

The purpose of the first time period of the slot, called the ramp-up, is to provide transmitter power stabilization and receiver AGC settling, which its time period is 0.41 ms. Syncword 27 symbols for training sequence are used for AGC, packet detection, time and frequency synchronization in the receiver. The Link Configuration Id 16 symbols define the channel configurations. Ramp-down and guard time periods provide time for the minimization of inter-packet interference due to delayed signal on radio channels and transmitted RF output etc. The following table 1 shows the definition of training sequence 27 symbols for synchronization functions.

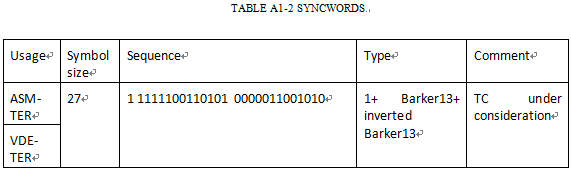


Table . Syncword 27 symbols

In general, coherent receivers for PSK and QAM can achieve ideal demodulation performance by performing PSK and QAM demodulation after signal level stabilization, timing synchronization, and frequency synchronization are carried out. Among them, achieving stabilization of the received signal level should be performed as first priority to all other synchronizations. A typical receiver of digital radio communication system converts an analog signal, such as an IF (Intermediate-Frequency), into a digital signal through an ADC (Analog to Digital Converter), and performs the demodulation function. In this process, the input signal is subject to clipping if the power of the signal input to the ADC is larger than the defined range, and if the received signal is too small, the quantization error becomes large. Both clipping and small signal states distort the received signal, making the degradation factor on the signal-to-noise ratio (SNR). To effectively solve such problem, an automatic gain control (AGC) for the signal level is used.

## Usable Symbol of Training Sequence for Signal Detection

In general, AGC requires certain time to stabilize the output level. If sufficient time for gain convergence is not secured at the AGC process, valid symbols that can be used in the signal detector are reduced. In addition, the valid symbols that can be used in other synchronization functions are also reduced, which ideal demodulation performance can’t be expected. Therefore, the AGC must be completed before signal detection and other synchronization functions are performed.

'Valid symbol usable in the signal detector' here means the symbol following the stabilization of AGC output. AGC signals prior to stabilization of output can be viewed as clipping or distorted signals with large quantization-error which are not suitable for signal detection.

In addition, in the VDES physical layer under the ITU-R M.2092 recommendation, as BW becomes larger, valid symbols of the training sequence usable in the signal detector are reduced. The reason for the reduction of valid symbols is that the time required to stablize AGC output is constant, while the time period corresponding to the training sequence becomes shorter in the high-speed transmission mode. The time corresponding to the valid symbol of the training sequence according to each Channel Bandwidth is as follows.

- ASM Ch. BW 13kHz 27 symbols @ 9.6ksps = 2.81ms

- VDE-T Ch. BW 25kHz 27 symbols @ 19.2ksps = 1.41ms

- VDE-T Ch. BW 50kHz 27 symbols @ 38.4ksps = 0.70ms

- VDE-T Ch. BW 100kHz 27 symbols @ 76.8ksps = 0.35ms

Considering the time required for AGC stabilization in the VDES packet structure, the number of available training sequences decreases as the transmission rate increases.

In the next section, performance of packet detection according to the number of training sequences is analysed through simulation tests.

## Detection-Performance with Number of Usable Training Sequence

In this section, we analyse detection performance made by the number of valid symbols used for signal detection.

The following signal detection performance is derived by retrieving the maximum correlation-peak between the received signal (range of detection determination: ∓1 sample on 4×fs) and the training sequence and analysed at the SNR corresponding to BER 1.0e-6 for TER-MCS-1.25 (pi⁄4 QPSK, FEC Rate: 1⁄2) mode.



Figure . Detection Probability with Usable Symbol of Training Sequence

|  |  |  |  |
| --- | --- | --- | --- |
| # of valid symbols | signal detection probability | False Alarm probability | comment |
| 21 | 98.6% | 1.4% | \* range of detection determination : [-1, +1] sample on 4\*fs  (fs: symbol rate) |
| 23 | 99% | 1% |
| 25 | 99.6% | 0.4% |
| 27 | 100% | 0% |

Table . Detection Probability with Usable Symbol of Training Sequence

As a result of the signal detection performance analysis, it is confirmed that the detection performance is reduced by about approximately 0.2 to 0.25% whenever the valid symbols usable for detection decrease by one. This detection probability degradation may be more severely affected by frequency offset, fading channel effects, Doppler etc.

# Suggestion

The fundamental reason why the number of symbols that can be used for signal detection among the training sequences received from the VDES receiver is reduced is because the training sequence is the only signal that can be used for AGC. In this proposal as a solution to this signal structure problem, we propose valid symbols transmission in Ramp-up period so that AGC can utilize Ramp-up period of the packet structure.

# Symbols in Ramp-up Period & SIMILAR standards

This section describes similar standards that have a burst structure and transmit valid symbols in the Ramp-up period, and proposes a Ramp-Up symbol patterns suitable for the VDES physical layer.

For the specification of burst structure similar to the VDES physical layer signal specification, there is a standard for the VHF Data Link (VDL) physical layer, which is a digital radio link used for communications between aircraft and ground stations [2], and a standard for the physical layer of Satellite Earth Stations and Systems [3]. Each standard specifies a certain pattern transmission for Ramp-up time period so that it can be used for receiving processing of AGC etc.

## VDL2 (VHF Digital Link, Mode2) [2]

In VDL2, data transmission shall begin with a demodulator training sequence consisting of five segments.

The purpose of the first segment of the training sequence, called the ramp-up, is to provide transmitter power stabilization and receiver AGC settling by transmitting five symbols over this period, and it shall be located in front of the first symbol of the training sequence. The Ramp-up time period also provides AGC settling time for the intended receiver.

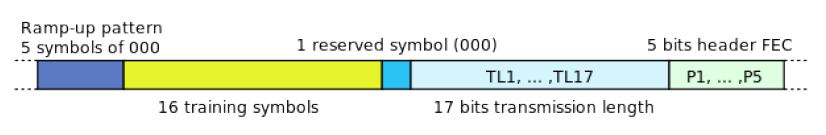


Figure . VDL MODE 2, Training Sequence Structure

As VDL2 equipment requirements, of the five symbols of Ramp-up period the transmitter must achieve an RF power rise for two symbols and a receiver AGC settling for the three symbols.

## SES; RSM-A (Satellite Earth Stations and Systems; Regenerative Satellite Mesh-A air interface) [3]

In SES; RSM-A specification, an uplink TDMA time slot is composed of a Start guard time period, a Ramp-up period, a TDMA burst, a Ramp-down time period, an End guard time period, and a Slot alignment time period, as shown in figure 4. And this specification defines that it can be used for receiving by transmitting a specific pattern during Ramp-Up period.

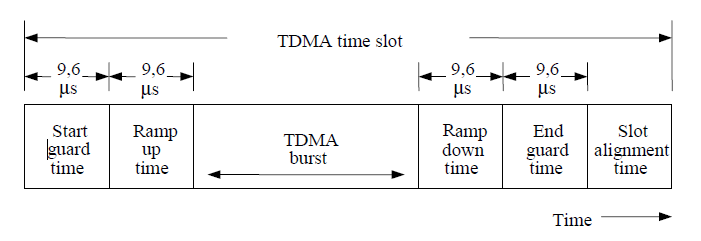


Figure . Uplink slot structure

The SES uplink Ramp-up pattern is defined in Table 3.

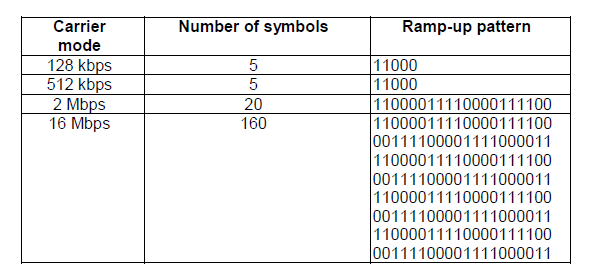


Table . Uplink slot ramp-up patterns

## Symbols in Ramp-up Period for VDES

As a result of the examination of these specifications, a signal suitable for the AGC to be transmitted in the Ramp-Up period is determined as a pattern signal of a constant level.

Meanwhile, higher demodulation performance is required because there are higher-order modulation modes such as 8 PSK and 16-QAM in the transmission mode defined by the VDES physical layer. And timing synchronization is required to satisfy such a demand.

Timing synchronization also requires sufficient time for stabilization, like AGC, therefore Ramp-Up period can be utilized.

In this proposal, we propose a repetitive pattern with a large variation in order to utilize AGC and timing synchronization for Ramp-Up period transmission symbols as follows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Link Config ID | | Ramp-Up Time (ms) | Ramp-Up  # of transmission symbols | Ramp-UP Pattern |
| ASM-TER  CH BW  16kHz | 1, 2, 3, 5, 6, 7, 8, 9, 10 | 0.41 | 4 | 1, 0, 1, 0 |
| VDE-TER  CH BW  25kHz | 11, 12, 13 | 0.41 | 8 | 1, 0, 1, 0, 1, 0, 1, 0 |
| VDE-TER  CH BW  50kHz | 14, 15, 16 | 0.41 | 16 | 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0 |
| VDE-TER  CH BW  100kHz | 17, 18, 19 | 0.41 | 32 | 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0 |

※ The Ramp-up Pattern is mapped like the Syncword of VDES:

1 is π/4 QPSK symbol 3 (1, 1), 0 is π/4 QPSK symbol 0 (0, 0).

Table 4. Ramp-up symbol patterns for VDES

# Conclusion

In this proposal, we examined the signal structure for VDES modem and AGC function as a synchronization function that should be applied first to the receiver for said signal structure.

It was analysed through simulation tests, that some signals of training sequence are used until the AGC output is stabilized and as a result, the number of valid symbols available in the signal detector is reduced.

From the above results, it is confirmed that the AGC output should be stabilized before the training sequence, and valid symbols transmission in the Ramp-Up period is suggested as a method for securing symbols necessary for AGC within the range of the recommendation.

In addition, we proposed a symbol that can be used for AGC and timing synchronization as transmission symbols within Ramp-Up period.

# References

1. Recommendation ITU-R M.2092-0+ (04/2017), Technical characteristics for a VHF data exchange system in the VHF maritime mobile band
2. ETSI EN 301 841-1 V1.4.1 (2015-04), “VHF air-ground Digital Link (VDL) Mode 2; Technical characteristics and methods of measurement for ground-based equipment; Part 1: Physical layer and MAC sub-layer”
3. ETSI TS 102 188-2 V1.1.2 (2004-07), "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 2: Frame structure"

# Action requested of the Committee

The Committee is requested to review the paper and take appropriate action.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)