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Maritime VHF-DSC monitoring with low cost SDR receiver

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Abstract. The main part of the alerting system of the GMDSS is done by automating alerting using Digital Selective Calling on VHF or MF/HF bands. Most of the small craft used to transport migrants use VHF-DSC to alert European's agencies of distress situations, which, in the all-most situations are fake. Because the maximum range of VHF propagation is around 50NM and it's related to the antennas' heights, it is necessary to increase the coverage area by installing many DSC receivers. The paper contains an example of a VHF-DSC receiver using a 20 Euros dongle and free GNU radio software. Instead to buy a maritime radio coast station the authorities can implement this system using low-cost dongle and small computers like Raspberry Pi, which also permit internet connection and IoT.

1. Introduction

The modern word is confronting with new problems like cybersecurity, mass fake news, migrants etc. It is a while since the EU is confronting with a very big number of migrants from conflict areas. There are many programs for supporting migrants from EU and also for stopping or limiting this fact.

One of the most important way of access in EU's countries is by ships. It is well known the business of the illegal migrant traffickers who embark as many people onboard of a small and unsafe ship in order to transport them in EU. Because of the over-embarking many of these ships have never arrived to their destination and became underwater cemetery. The lucky ones arrive close to the EU's shore and send a distress alert by VHF DSC, AIS-EPIRB, EPIRB etc. Because of the poor navigation equipment of the boats/ships the migrants arrive in unpredictable areas. This is the reason we have chosen to develop a cheap DSC receiver which can be implemented very easily along the EU's shore. We used this research for inspiration and state-of-the-art[1]–[3].

The paper present a solution of a maritime VHF-DSC receiver using a cheap USB dongle (SDR receiver), a Raspberry Pi development board with Raspbian free operating system, a decoding program based on GNU Radio Companion and a monitor with HDMI interface.

2. DSC – Digital Selective Calling - preview

The DSC communication is intended for transmitting short pager messages between two or more radio station. In 1992, the IMO introduced Digital Selective Calling on MF, HF and VHF maritime radios as part of the GMDSS system. Since 1999 GMDSS regulations, which include DSC radio equipment, are compulsory for all commercial vessels over 300 grt, registered fishing vessels and craft vessels carrying more than 12 passengers.

There are four types of calls in maritime communications: distress, urgency, safety and routine. In order to have a digital selective call the ships must be registered for a MMSI number. MMSI stands for Maritime Mobile Service Identity. There are four types of MMSI numbers:

- *Coast station identities*: have MMSI numbers starting with "00" followed by the MID code and a 4-digit station number.
- *Ship station identities*: have MMSI numbers that start with the MID code followed by a 5-digit identification number and end with "0".
- *Group ship station identities*: A group of ship stations may be assigned one single MMSI. The group MMSI will start with "0" followed by the MID code and a 5-digit group identification number.
- *Group coast station identities*: also a group of coast stations may be assigned a single MMSI. As for a single coast station this MMSI will also start with "00".

The transmitted DSC message it is received and decoded by the all station from vicinity but it is displayed only by the addressed station which will further process the transmitted message. DSC also features a broadcasting ("to all ships") or a group call service for distress and emergency calls.

2.1 ITU Recommendation for DSC - Rec. ***Error! Use the Home tab to apply href to the text that you want to appear here.***

"*The classes of emission, frequency shifts and modulation rates are as follows:*

A) F1B or J2B 170 Hz and 100 Bd for use on HF and MF DSC calling channels. When frequency-shift keying is effected by applying audio signals to the input of single-sideband transmitters (J2B), the centre of the audio-frequency spectrum offered to the transmitter is 1 700 Hz. When a DSC call is transmitted on HF and MF working channels for public correspondence, the class of emission is J2B. In this case, audio tones with frequencies 1 700 Hz □ 85 Hz and modulation rate 100 Bd are used in order for the DSC call to be transmitted.

B)G2B for use on VHF DSC calling Channels. Frequency modulation with a pre-emphasis of 6 dB/octave (phase modulation) with frequency-shift of the modulating sub-carrier for use on VHF channels:

- *frequency-shift between 1 300 and 2 100 Hz; the sub-carrier being at 1 700 Hz;*
- *the frequency tolerance of the 1 300 and 2 100 Hz tones is ± 10 Hz;*
- *the modulation rate is 1 200 Bd;*
- *the index of modulation is 2.0 ± 10%.*"

3. Low cost Software Defined Radio receiver

Radio components such as modulators, demodulators and tuners are traditionally implemented in hardware components. The advent of modern computing allows most of these traditionally hardware based components to be implemented into software instead. Hence, the term software defined radio. This enables easy signal processing and thus cheap wide band scanner radios to be produced[4].

Figure 1. An example of low-cost SDR: RTL-SDR is a very cheap software defined radio that uses a DVB-T TV tuner dongle based on the RTL2832U chipset.

3.1Basic Information

- Bandwidth: Up to 2.4 MHz stable.
- ADC: RTL2832U 8-bits
- Frequency Range: 500 kHz – 1766 MHz (500 kHz – 24 MHz in direct sampling mode)
- Typical Input Impedance: 50 Ohms
- Typical Current Draw: 270 – 280 mA

4. GNU Radio Companion

GNU Radio is a free & open-source software development software that provides signal processing virtual instruments to implement software radios. It can be used with readily-available low-cost external RF hardware to create software-defined radios, or without hardware in a simulation-like environment. It is widely used in hobbyist, academic and commercial environments to support both wireless communications research and real-world radio systems[5], [4], [6]–[8].

An example of a G2B (phase modulation) demodulation is presented in Figure 3. But for better implementation and redundancy we chose to use a professional decoder program based on GNU Radio Companion.

We tested the following decoding programs: DSCdecoder[9], Transoceana DSC decoder[10], Multipsk[11] and Mimer soft-radio. The best price/quality in our opinion is Mimer soft-radio.

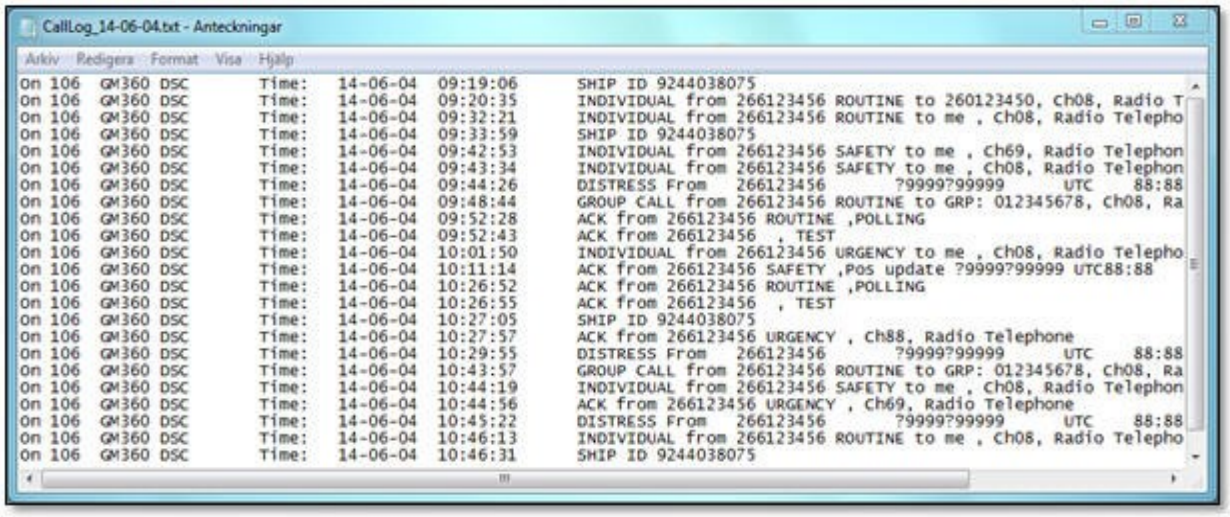

Figure 2. Decoding sequences of Mimer soft-radio

5. VHF-DSC Receiver architecture

The monitoring system is based on Raspberry Pi V3 which can easily accessed remotely and also be implemented in IoT network. It has WiFi and Ethernet capabilities. Also, the operation system is based on free Debian and it is called Raspbian. There is a good support for USB dongles drivers and also SDR softwares, because most of them are based on GNU.

The SDR dongle is connected to the Raspberry Pi via USB interface, which also provide power. The dongle works as a receiver, amplifier and Analog to Digital Converter. The Digital Processing is performed in Raspberry using Mimer soft-radio. The information is displayed on a local monitor or can be upload to a server or accessed remotely. This architecture has a small power requirement and can be installed in isolated areas using renewable energy sources.

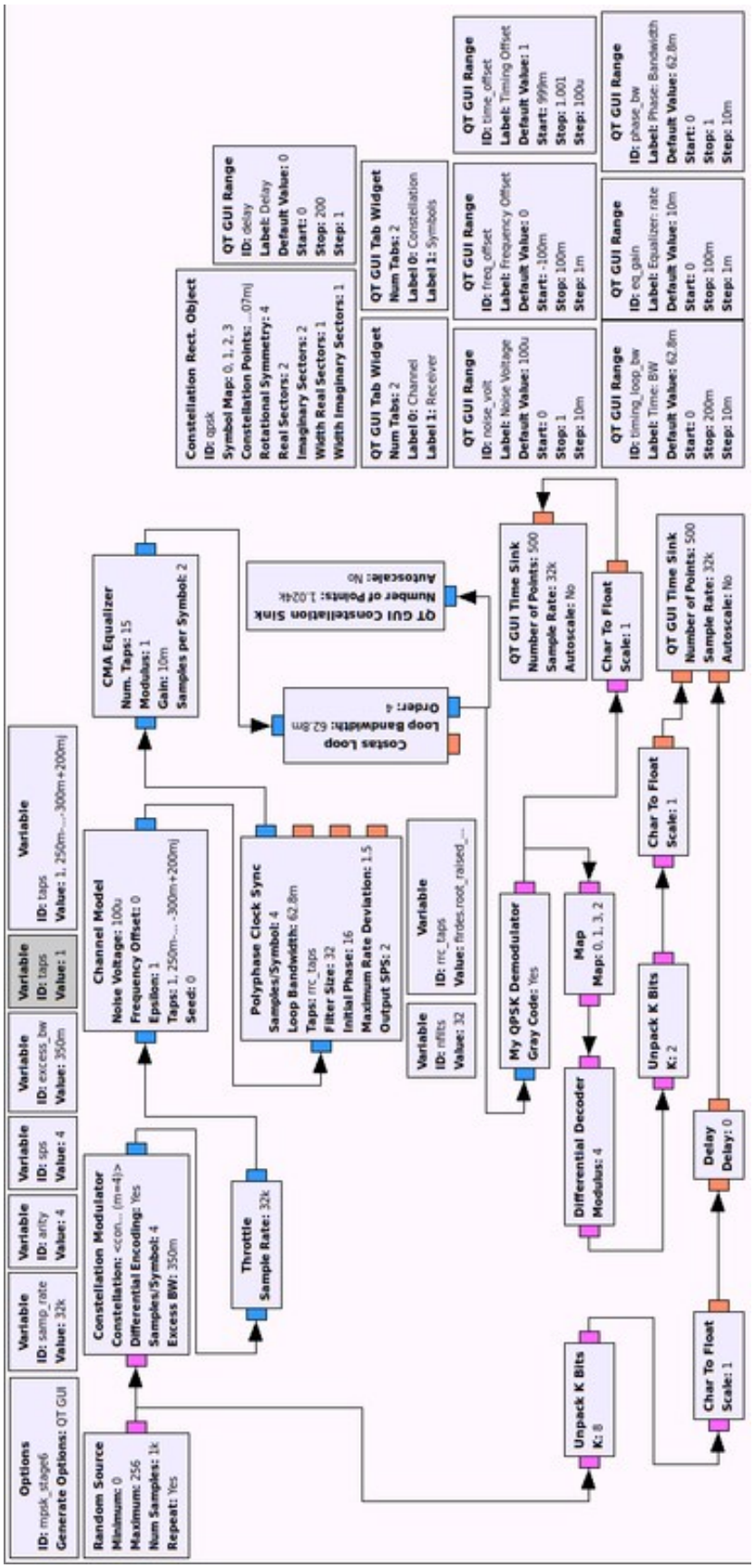

Figure 3. QPSK demodulation block diagram in GNU Radio

6. Conclusions

The main objective of the paper is to present a low cost DSC receiver for monitoring Distress and Urgency alerts along the EU's coast to Black Sea and Mediterranean Sea. The researchers tested an architecture based on Raspberry Py, an SDR receiver based on RTL2832U chipset and decoder programs based on GNU Radio Companion. The results showed that this system can be implemented in DSC monitoring activities for costs per system less than 100Euros.

In the future the researchers will try to develop a free GNU Radio Software for decoding DSC and AIS signals, which will be implemented in this architecture.

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