A Low Cost COSPAS-SARSAT Transponder

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Abstract:- Calamities at sea are unpredictable. Many fisher men lose their lives without any aid. With the advancement of technology, nowadays there are various kinds of Emergency Position Indicating Radio Beacon, SAR Transponder, and Emergency Personnel Locators available in the market. One of the leading and most successful EPIRB is COSPAS-SARSAT; a satellite based SAR Transponder which is available for maritime use. But these devices are expensive and not affordable by the fishermen living their life below poverty line. This emerges the need of a low cost COSPAS-SARSAT, which is efficient, easily readable and affordable by a common civilian. In this paper, we will discuss and propose a low cost solution to the COSPAS-SARSAT transponders, which is based on GPS and Radio Beacons, relatively low in cost yet reliable.

Keywords: Transponder; SAR; EPIRB; GPS; RF Propagation.

I. INTRODUCTION

The total length of the world's coastlines is about 504,000 km, enough to circle the Equator 12 times. Coastal areas comprise 20% of the Earth's surface yet contain over 50 per cent of the entire human population. By the year 2025, coastal populations are expected to account for 75% of the total world population. More than 70% of the world's megacities (greater than 8 million inhabitants) are located in coastal areas. Half of the world's cities with more than one million people are sited in and around estuaries.

The threats to coastal communities include extreme natural events such as hurricanes, coastal storms, tsunamis, and landslides, as well as longer-term risks of coastal erosion and sea level rise. The total number of commercial fishermen and fish farmers is estimated to be 38 million around the world, past decade they are continuously threatened by marine calamities, sea pirate attacks, natural and man-made disaster also.

According to the International Maritime Bureau the number of sea pirate attacks in Bangladesh jumped three-fold to 11 in 2017. Every year they face attack from the pirates of Bay of Bengal which made the life of fishermen at sea and coastal area very tough.

Most commercial fishermen are low-caste Hindus who eke out the barest subsistence working under primitive and dangerous conditions. Every time they set out to the sea to fish, they gamble with their own lives. A total of 11 piracy events took place off the coast of Bangladesh in 2012.In the last five years; pirates have killed at least 411 fishermen and wounded at least 1,000 more. Not only Bangladesh, but a lot of countries around the world suffer from marine distress as hurricanes, tropical storms, tsunamis, and landslides have the potential to generate a tremendous amount of marine debris. Recent marine distress occurred at Kerala over 483 people died, and 14 are missing.one-sixth of the total population of Kerala had been directly affected by the floods and related incidents.

Advancement in the technology offers various distress signal mechanisms such as EPIRB, GMDSS, SAR transponders, ELTs, PLBs etc. COSPASS-SARSAT is one of the most popular and effective for global coverage. Also GMDSS is another popular distress signaling mechanism for ship to shore distress signaling. Both of them are expensive solution in terms of Bangladesh and this creates a need of an alternative Emergency Position-Indicating Radio Beacon (EPIRB) solution, which is easy to build, operate and also effective at a budget, so that it can be installed in every fishing boats.

In this paper we will discuss about a possible solution for the above problem, propose a system design for low cost COSPASS-SARSAT. In section 2 mentions about different currently available devices and their working principle. We will also discuss about the requirement for the low cost COSPASS-SARSAT section 3 contains the block diagram and details for the proposed system. Section 4 explains about the hardware design. Section 5 is about the software design for the system. Section 6 is the result of the first test run. Finally we will close our discussion by our conclusion on the topic, which will help us to design a low cost maritime EPIRB, which may save a lot of life of those fishermen in the sea.

II. LITRATURE SURVEY

For the design of the system we need to know about the current devices and its working principle. For the software development of the system we need to know about the cospass sarsat handbook of beacon regulations. Current available two popular maritime distress signalling methods are COSPAS-SARSAT and the other one is the GMDSS. Both of them are discussed in brief below:

Cospass sarsat: Cospas-Sarsat is best known as the system that detects and locates emergency beacons activated by aircraft, ships and people engaged in recreational activities in remote areas, and then sends these distress alerts to search-and-rescue (SAR) authorities. Distress beacons capable of being detected by the Cospas-Sarsat System (406-MHz beacons) are available from several manufacturers and vendor chains. Cospas-Sarsat does not make or sell beacons. Fig. 1 shows the most common type of cospass sarsat device.The system consists of a ground segment and a space segment that include:

Distress radio-beacons to be activated in a life-threatening emergency SAR signal repeaters (SARR) and SAR signal processors (SARP) aboard satellites Satellite downlink receiving and signal processing ground stations called LUTs (local user terminals) Mission Control Centres (MCCs) that distribute to Rescue Coordination Centres distress alert data (particularly beacon location data) generated by the LUTs Rescue Coordination Centres (RCCs) that facilitate coordination of the SAR agency and personnel response to a distress situation.

Ref [4] has very detail of COSPAS-SARSAT with its working principle and system composition. Regardless of ease of use, each of these device price ranges from US$ 400.00 and these requires registration to COSPAS in order to identify any terminal activated in distress. Nowadays most of the merchant marine vessels are equipped with it, but local fishermen in Bangladesh are not equipped with it yet.

2.1 COSPAS SARSAT Devices

GMDSS: The Global Maritime Distress and Safety System (GMDSS) is an internationally agreed-upon set of safety procedures, types of equipment, and communication protocols used to increase safety and make it easier to rescue distressed ships, boats and aircraft. The main types of equipment used in GMDSS are EPIRB, NAVTEX, Satellite, search and rescue locating device, digital selective calling. Ref [5] details of the above-mentioned equipment.

GMDSS sea areas are classified in four areas: A1, A2, A3 and A4. sea area A1 within the radiotelephone coverage of at least one VHF coast station in which continuous digital selective calling (Ch.70/156.525 MHz) alerting and radiotelephony services are available. Such an area could extend typically 30 to 40 nautical miles (56 to 74 km) from the Coast Station. Sea area A2 within a coverage of at least one coast station continuous listening on MF (2187.5 kHz) other than Area A1. Sea area A3 excluding sea areas A1 and A2, within the coverage of an Inmarsat geostationary satellite. This area lies between about latitude 76 Degrees North and South, but excludes A1 and/or A2 designated areas. Inmarsat guarantees their system will work between 70 South and 70 North though it will often work to 76 degrees South or No. Sea area A4, an area outside Sea Areas A1, A2 and A3 is called Sea Area A4. This is essentially the polar regions, north and south of about 76 degrees of latitude, excluding any A1, A2 and A3 areas. Bangladeshi fishermen work mostly in Sea Area A1 and some go beyond A1, but does not reach A2.

Many of the merchant marine vessels nowadays are equipped with GMDSS radios, but still it is not so popular in Bangladesh due to need of registration of each station. Also, GMDSS enabled radios are costly in comparison to Bangladesh economy and especially for local fishermen.

2.2 GMDSS Devices

III. COSPASS SARSAT HANDBOOK OF BEACON REGULATION

This document provides a summary of regulations issued by Cospas-Sarsat Participants regarding the carriage of 406 MHz beacons. It also includes practical information on coding and registration requirements in each country, where such information was made available to the Cospas-Sarsat Secretariat.

It also includes the following information:

The list of type approved beacons, details on points of contact for beacon matters and beacon test facilities information. Examples of beacon registration cards are not included in the document, but are available at the Secretariat and can be provided on request. This document is based mainly on information provided by Participants at Cospas-Sarsat meetings and in reports on System status and operations. Some information was provided by non-

Cospas-Sarsat Participants. However, regulations are likely to evolve and the attached information should not be regarded as an official record of their current status. Participants are invited to provide the Cospas-Sarsat Secretariat with updates as appropriate.

Ref [1] will give the detailed hand book of beacon regulation.

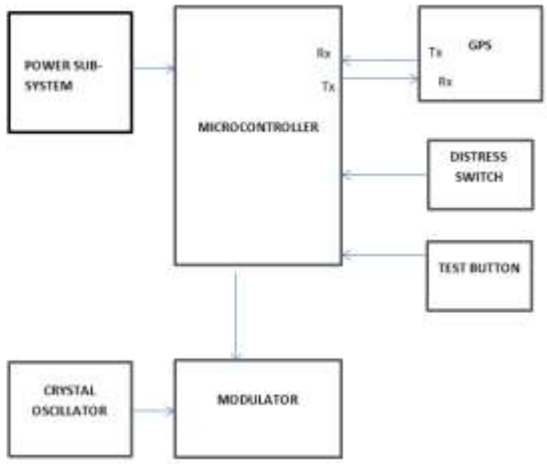
IV. BLOCK DIAGRAM

Our goal is to send the location data of a fishing boat in distress to shore over RF, the EPIRB Transponder will be installed on a fishing boat as a single box device with built-in power source. The device will have two buttons, one is test button and other is an emergency button. A TEST BUTTON will send test values to ensure the proper working of the system, but will not send distress, it can be activated only once. The EMERGENCY BUTTON will send the distress signal i.e. the location data of the boat. The all-in-a-box device will only have at least 2 RF connectors, where on is for receiving GPS signals and the other one is to the beacon-transmitting antenna. In case of multiple transmissions like one for distress position reporting and other for local homing beacon (like COSPAS-SARSAT's 406MHz and 121.5MHz pair), there may be multiple RF-OUT connectors for different radiating antennas. But in our system, we are not inserting local homing beacon as it is not necessary.

On pressing the emergency button, a fully functional EPIRB will be powered on and will lock itself with the GPS satellites.

Once locked, the GPS data (position coordinates) will be transferred to the onboard processor and processor will convert the position data into regular format from NMEA 0183 format [as most GPS gives readout in NMEA 0183 format]. The processor will also prepare the distress message. Then the processor will encode the position report to the signalling method of desire like PSK or OOK, etc. After this, the encoded data will be transmitted on the air using the radio transmitter(s) for sending the position data. The proposed EPIRB will be comprised of the following blocks [fig2]:

GPS sub-system: This sub-system is a plain GPS module capable of detecting GPS satellites for Lat-Lon coordinates and local time. The output is NMEA 0183 format, so that it is universal and easy to interface with any system. While selecting a GPS module, parameters like start-up time, satellite locking speed, power consumption, etc. should be carefully considered for price vs. performance.



4.1 Block Diagram

Controller sub-system: This is the heart of the whole system, which will be connected to other sub-systems of the whole device. This is responsible for entire message creation and encoding along with sending data to transmitter and to act like a transponder by sending position data at an interval.

Modulator sub-system: To modulate the encoded information with carrier and transmit it to the RF section of the system. Here the carrier must be a high frequency signal to avoid signal attenuation. Output of the modulator is a digital PSK signal so that we will be able to distinguish the message signal from the noise at the receiver end.

Crystal oscillator: Temperature compensated crystal oscillator (TCXO)are used to achieve high level of accurate and stable high frequency carrier signal. It provides a means of counter acting the frequency change caused by temperature change in a crystal oscillator.

Power sub-system: The power sub-section is self-explanatory. This will pro-vide power to the entire transponder to operate. This can be any DC power source, inbuilt to make the entire transponder a single box device. This will be comprised of battery banks as power storage and also power supply circuits and power regulators for various sub-systems. For our particular case, we are not proposing any PV array as an alternative power source for keep the battery standby. As the device will be turned on during distress only, the power in the device will be stored for a long time. But as batteries have self-discharge, we propose here for firstly Li-Ion batteries for extended life and less weight. Also, we are proposing to avoid hi grade Li-Ion batteries to reduce price. Instead, a charging mechanism can be either inbuilt or a separate charger can be used to charge the transponder during boats maintenance time after each sail.

V. HARDWARE DESIGN

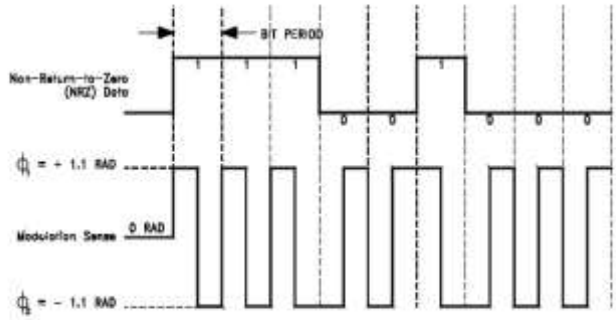
As per the regulations each component needs to satisfy certain features requirements.

Controller: The general guidelines for the overall beacon the digital controller was low cost, low parts count, and, if possible, low power, because the beacon is powered by a battery. It requires 256×4 PROM and a 1K×4PROM to hold the software. It must meet the 406-MHz beacon temperature requirements. The 256x4 PROM is used for storing beacon-specific data (i.e., user ID, country code, etc.). Having the beacon-specific information stored on a PROM allows for easy, inexpensive programming of individual beacons.

The 1Kx4 PROM is used to encode switch settings which specify the emergency code. Having the PROM encode the switch settings allows the switch to be simple and inexpensive, thus increasing the reliability of the overall circuit. Also, by using a PROM, the same circuit can generate any 4-bit emergency code.

GPS module: GPS MODULE the NEO-6 module series is a family of stand-alone GPS receivers featuring the high-performance u-blox 6 positioning engine. These flexible and cost-effective receivers offer numerous connectivity options in a miniature 16 x 12.2 x 2.4 mm package. Their compact architecture and power and memory options make NEO-6 modules ideal for battery operated mobile devices with very strict cost and space constraints. The 50channel u-blox 6 positioning engine boasts a Time-To-First-Fix (TTFF) of under 1second. The dedicated acquisition engine, with 2 million correlators, is capable of massive parallel time/frequency space searches, enabling it to find satellites instantly. Innovative design and technology suppress jamming sources and mitigates multipath effects, giving NEO-6 GPS receivers excellent navigation performance even in the most challenging environments.

Modulation: The carrier shall be phase modulated positive and negative (1.1) +/- (0.1) radians peak, referenced to an unmodulated carrier. Positive phase shift refers to a phase advancerelative to nominal phase. The rise (tr) and fall (tf) times of the modulated waveform, shall be (150 + 100) us. Modulation symmetry shall be such that: 0.05.



5.1 Encoding and Modulation sense

Antenna:

Elevation : 5° to 60
Pattern : Hemispherical
Polarization : Circular (RHCP) or linear
Gain (vertical plane) : Between – 3 dBi and + 4 dBi over 90% of the above region
Gain variation (azimuth plane) :< 3 dB
VSWR (7) : ≤ 1.5: 1

VI. SOFTWARE DESIGN

The software design accomplishes COSPAS SARSAT prescribed encoding of positional data along with the vessel identification details, Bi-phase L modulation and the offset required for the modulation. This is established by the extraction of coordinate data from GPRMC format in NEO 6M GPS module. The extracted coordinates are converted to prescribed latitude and longitude format.

On the activation of distress button, the extracted details are added to form the long message format. In the testing mode only the vessel details and default coordinates are added. Two stages of BCH coding are performed in different frame sections. The offset and random delays are added and transmitted through the serial port. The serial stream is used in the modulation section.

VII. RESULT

We mainly focused on the message signal generation rather than transmission side, as signal generation is the most crucial part of the design. Obtained signal need to be power amplified to 5W before transmission. After amplifying the signal, it is to given to appropriate antenna which meet the regulations. As per the regulations specified in COSPAS SARSAT Handbook, the controller coding is done. For the Testing the EPIRB, the test switch has to be activated, which results in code control entering the test message generation module. The frame synchronization is added to the message and id BCH encoded and transmitted to Biphase generating circuit after adding a offset delay. On the activation of distress switch, the GPS coordinates are extracted into the specified format. The location data is added to the message and is BCH encoded. The final message is converted to software Biphase and with the addition of offset it is transmitted ted to the Biphase circuit. We will obtain the biphased signal as the output.

VIII. CONCLUSIONS:

The alternative EPIRB transponder of COSPAS-SARSAT will serve as a locally developed transponder in low cost. As this transponder will use the GPS for positioning data, a boat in distress can easily send its position to monitoring authorities on a single push of a button. Also, for medium distance transmission, when HF will be selected, the coverage range will be a broad range and if multiple MCCs are available or MCCs with Aux-MCCs available, all will get almost the same data, hence they can double check for false alarm. Also, since signal may be received by more than one MCC, error in data can be easily detected, as in this case at least one MCC will have always better chance to receive stronger signal than rest others. When each transponder will have their own ID, maintaining a database and registration process will make identification of the boat more user-friendly. In a formatted distress message, for 3rd party listeners like merchant vessels, amateur radio operators or other disciplines, it will be also easy to read the distress and relay the message to concerning authority.

The COSPAS-SARSAT transponders have a battery life of around 5 years and they require to inspection from time to time for confirmed operation. As long-lasting high-power batteries are expensive, the alternative approach can be recharging of batteries during mooring of the fishing boats. This will reduce the price and will help to keep the power at hand. Local fishing boats are made of mostly wood and are good for RF transmission as less chance of interference due to metal body. Also, as seawater is saline water, it can be a good conductor and thus the need of a "good ground" becomes very handy by putting the ground wire in water. This will also improve RF emission and overall, a relatively good transmission can be achieved with the position data, so that many lives can be saved who might be in distress at sea during fishing.

IX. REFERENCES

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