Lecture Notes in Electrical Engineering 365

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Editors

Proceedings of Second International Conference on Electrical Systems, Technology and Information 2015 (ICESTI 2015)

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Contents

Introduction

This book includes the original, peer-reviewed research papers from the 2nd International Conference on Electrical Systems, Technology and Information (ICESTI 2015), held during 9–12 September 2015, at Patra Jasa Resort & Villas Bali, Indonesia.

The primary objective of this book is to provide references for dissemination and discussion of the topics that have been presented in the conference. This volume is unique in that it includes work related to Electrical Engineering, Technology and Information towards their sustainable development. Engineers, researchers as well as lecturers from universities and professionals in industry and government will gain valuable insights into interdisciplinary solutions in the field of Electrical Systems, Technology and Information, and its applications.

The topics of ICESTI 2015 provide a forum for accessing the most up-to-date and authoritative knowledge and the best practices in the field of Electrical Engineering, Technology and Information towards their sustainable development. The editors selected high quality papers from the conference that passed through a minimum of three reviewers, with an acceptance rate of 50.6 %.

In the conference there were three invited papers from keynote speakers, whose papers are also included in this book, entitled: “Computational Intelligence based Regulation of the DC bus in the On-Grid Photovoltaic System”, “Virtual Prototyping of a Compliant Spindle for Robotic Deburring” and “A Concept of Multi Rough Sets Defined on Multi-Contextual Information Systems”.

The conference also classified the technology innovation topics into five parts: “Technology Innovation in Robotics, Image Recognition and Computational Intelligence Applications”, “Technology Innovation in Electrical Engineering, Electric Vehicle and Energy Management”, “Technology Innovation in Electronic, Manufacturing, Instrumentation and Material Engineering”, “Technology Innovation in Internet of Things and Its Applications” and “Technology Innovation in Information, Modeling and Mobile Applications”.

In addition, we are really thankful for the contributions and for the valuable time spent in the review process by our Advisory Boards, Committee Members and Reviewers. Also, we appreciate our collaboration partners (Petra Christian

University, Surabaya; Gunadarma University, Jakarta; UBAYA, Surabaya, University of Ciputra, Surabaya, Institute of National Technology, Malang and LNEE Springer, Germany), our supporting institution (Oulu University, Finland, Widya Mandala Catholic University, Surabaya and Dongseo University, Korea) and our sponsors (Continuing Education Centre, Petra Christian University, Surabaya and Patrajasa Resort Hotel, Bali).

On behalf of the editors Felix Pasila

Part I
Invited Speaker

Chapter 32
Innovative Tester for Underwater Locator Beacon Used in Flight/Voyage Recorder (Black Box)

Hartono Pranjoto and Sutoyo

Abstract All commercial airplanes that carry more than 20 passengers and all sea merchant vessels with sizes above 3000 gross tonnage must be equipped with flight/voyage data recorders or more popularly known as black box. All black boxes aboard those vessels must be equipped with a completely independent ultrasonic sonar finder device called Underwater Locator Beacon (ULB). In case the device is immersed in water due to an accident, this device will emit ultrasonic signal at 37.5 kHz of a certain pattern for 30 days. The chance of finding the vessel (an airplane or a ship) sinking in the ocean is almost solely depend on the working order of this device. The work presented here is about testing the ULB for its performance using simple system by the use of a microprocessor. The tester will check the voltage of the battery inside the ULB, the expected length of usage of the battery, the generation of the ultrasonic signal at 37.5 kHz, and also about the pattern of the signal. The device designed and built will be small and easy to use with good visual and audio feedback to indicate the result of the UTB test. At the termination of this work, a working system to test a ULB on the voltage and also detection of the ultrasonic signal has been built which is small and intelligent. The usage of the system is very simple, just by inserting the ULB into the system and pressing the unit for 5 s, a thorough result of the ULB test is presented on an LCD screen together with a blinking color light emitting diode (LED) and audible sound via buzzer to prove that the ULB under test is in good working order.

Keywords Flight recorder tester · Under water locator beacon · Flight black-box

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32.1 Introduction

All commercial airplanes that carry more than 20 passengers and all sea merchant vessels with sizes above 3000 gross tonnage must be equipped with flight/voyage data recorders or more popularly known as black box. The actual color of the recording unit is actually bright orange color with marking that the device is a flight or voyage data recorder. For an airplane there are two different and independent unit of data recorder, one data recorder is for the cockpit voice data recorder which record all conversation taking place inside the cockpit and a flight data recorder which record all the parameters of the flight such as heading, altitude, position of rudder, position of elevator and many other parameters All black boxes aboard those vessels must be equipped with a completely independent ultrasonic sonar finder device called Underwater Locator Beacon (ULB). In case the device is immersed in water due to accident, this device will emit ultrasonic signal of a certain pattern for 30 days [1–3].

Figure 32.1 shows the recording unit for an airplane. Figure 32.1a is a typical photograph of a cockpit audio voice data recorder (CAVR) while Fig. 32.1b is a photograph of a flight data recorder. There no significant difference between those two devices. Figure 32.1c is a typical photograph of voyage data recorder usually found above the bridge of a sea vessel.

In all figures above (Fig. 32.1a, b, c) although they are built by different manufacturers there is one common unit—the ULB—shown as white cylinder on the right hand side of the recorder (Fig. 32.1a) on the left hand side of the recording unit (Fig. 32.1b) and above the recording unit (Fig. 32.1c). The length of a ULB is 10 cm and the diameter is 3.3 cm. A detailed view of the beacon and example of mounting on FDR is shown in Fig. 32.2a, b.

A ULB by itself when stored anywhere—such as mounted next to a data recorder—will not transmit any ultrasonic signals because the positive pole and the body of the ULB is not connected or it is an open circuit. Upon completion of the circuit such as shorting the positive pole to the body or by immersing the ULB underwater—thus create a short circuit, then the ULB will emit ultrasonic signal. The ultrasonic signal will have a frequency of 37.5 kHz ± 1 kHz. The frequency will be transmitted for a period of 10 ms (0.01 s) with a silent period of 99 ms (0.99 s) to provide a period of 1 s modulation. Figure 32.3 shows the timing and the ultrasonic pulses emitted by the ULB. Figure 32.3a shows in illustration of how to short the positive pole to the body of the ULB using simple wire and Fig. 32.3b shows the ultrasonic output of the ULB. From Fig. 32.3b, it shows clearly that the frequency output of the ultrasonic is 37.5 kHz and the active period of 10 ms. During the remaining 990 ms, the ULB does not transmit any ultrasonic signal thus giving a period of 1 s of modulation period [1–6].

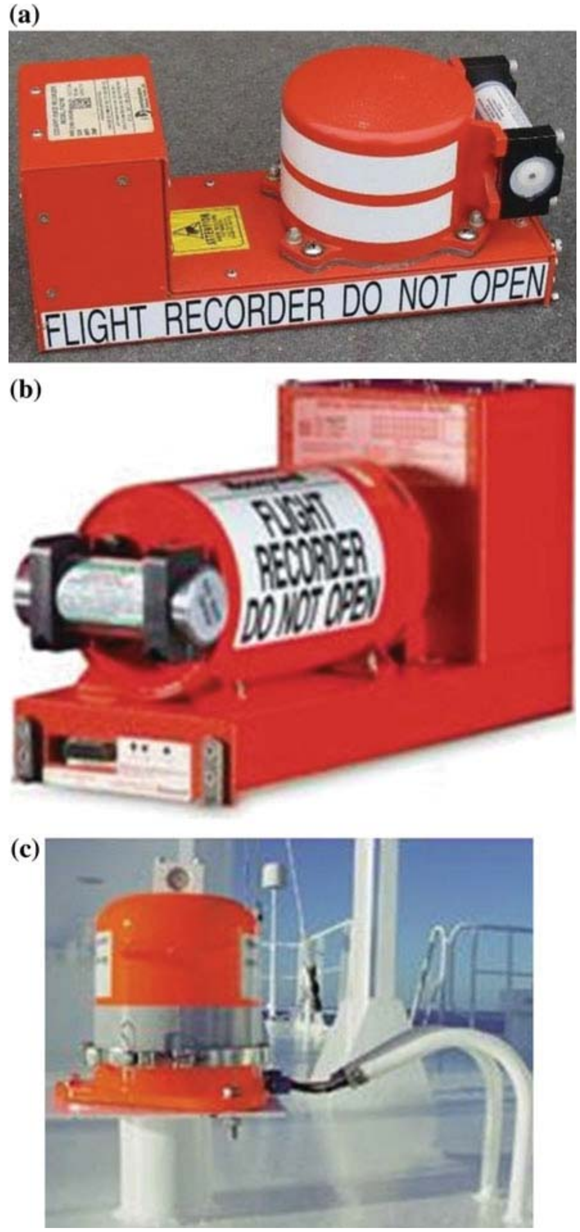

Fig. 32.1 **a** Cockpit audio voice recorder unit of an airplane. **b** Flight data recorder of an airplane. **c** Voyage data recorder for sea vessel

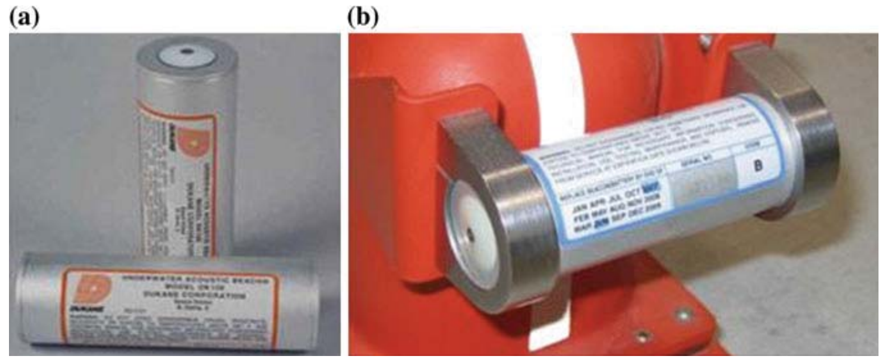

Fig. 32.2 **a** Detailed view of a ULB on with the positive node shown on the vertical unit. **b** ULB mounted on the side of an FDR shown together with the expiration date (June, 2007)

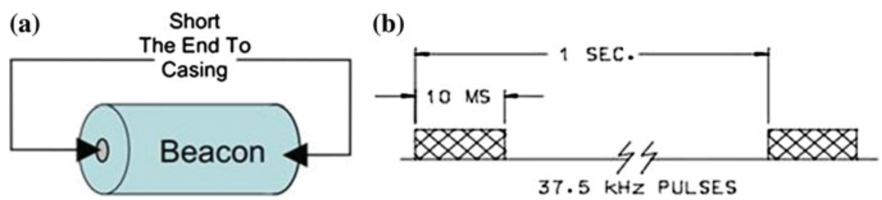

Fig. 32.3 **a** Activation of ULB by shorting the positive pole to the body of the beacon. **b** Timing of the ultrasonic pulses emitted by the ULB

32.2 Annual Performance Test of ULB

By regulation, the CAVDR, FDR, or VDR must be tested at least once a year by a qualified personnel endorsed by the maker of the corresponding maker. After the test is performed, temporary certificate is given by the personnel when he/she thinks the unit is working in satisfactory condition. Later on, the data must be sent to the maker and the maker will review the result, and if the maker is satisfied, then a 1-year certificate for the unit is issued.

During the test, most of the work is on the recording unit, the ULB is only checked for the battery expiration and the voltage of the battery. No test is usually performed to check for the performance of the ultrasonic transmitter, although this is the only chance of finding the data of the recording unit if the vehicle is immersed underwater.

There are manufacturer that provide ultrasonic test, but the test is cumbersome. It involves taking the battery out of the mounting unit, short the pole and the body similar to Fig. 32.3a, and then place an ultrasonic transducer near the ULB to listen to the signal. This task is not easy because the location of the unit is not easy to reach and also to work with and therefore performing the task of testing the ULB becomes more demanding.

32.2.1 Testing the Underwater Locator Beacon (ULB)

The most important parameter of testing the Underwater Locator Beacon (ULB) is (1) to check the expiry date of the lithium battery of the beacon, (2) testing the voltage of the lithium battery to be within certain value (above 2.97 V) and (3) test if the ULB transmit ultrasonic signal with the predetermined pattern. The first two tasks have been performed traditionally by the surveyor, but to test the actual transmission is not performed because the device currently used is cumbersome. In this tester, the last two tasks will be performed very easily just by pushing the ULB into the socket inside the tester. The tester will perform a self test itself, then check the battery voltage of the ULB and then test the presence of ultrasonic signal from the ULB.

Testing the ULB can be performed by using one simple task b inserting the ULB inside the opening of the testing unit. Upon pressing the ULB into the test unit, there is a small switch that turns on the entire system and start the sequence of ULB testing will be as follows:

(1) Do a power on self test on the ULB tester to ensure that the tester is in good working order such as the battery voltage supply, the buzzer, LCD and LED indicator
(2) Do a voltage measurement of the lithium battery of the ULB and predict based on the voltage the length of time the battery will last for storage. If the prediction of the lifespan of the battery is less than 1 year, the system will show a warning.
(3) Short the positive probe and the body of the ULB and then the ultrasound microphone will listen for the ultrasonic tone of the ULB at certain voltage level. The microprocessor will count the number of pulses to ensure that there are between 365 and 385 pulses within the 10 ms of the transmission windows

After all sequence described above is passed, then the unit will show a satisfactory condition which is shown on the LCD, blink of the green LED and also single beep of the buzzer.

32.3 Description of the ULB Tester

The main unit of the ULB tester is a microcontroller ATMEGA88PA SMD—to make the entire device small in size—and a ultrasonic transducer as shown in Fig. 32.4. When the ULB is inserted and then pressed, the start button will turn on the microprocessor, do a self test within 300 ms, and then measures the voltage of the lithium battery to a specific voltage (3 V) several times. The unit will then shorted the body of the ULB with the positive probe to start the transmission of the ultrasonic signal at 37.5 kHz. The signal is then picked up by an ultrasonic

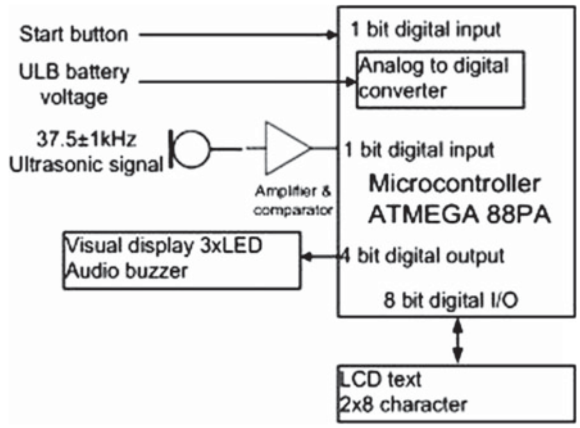

Fig. 32.4 Block diagram of the innovative ULB tester

transducer and then amplified/compared with an op-amp. The output is fed to the microcontroller that measures the number of pulses to be between 375 pulses ± 10 %—a 37.5 kHz signal will generate 375 pulses within 10 ms. This detection is performed three times. After all measurements are finished, a single audible beep is generated together with the lighting of the green LED (light emitting diode) and the word "PASSED" and Volt = 2.98 to indicate the voltage of the lithium battery on a 2 × 8 character text LCD.

The first ULB tester is quite compact measuring only 13 cm in length as shown in Fig. 32.5 along with a measuring ruler on the bottom side. The casing is made of acrylic to show all the components. On the left side is the opening to insert the ULB under test and then push the ULB to start the entire sequence of testing from measuring the battery voltage and then check the presence of ultrasonic signal when the ULB is shorted. Shown on top of the tester is the 2 × 8 character text LCD. Underneath the LCD is the microcontroller with all the connection to the other peripherals. On the bottom part of the microcontroller board is the power supply board and the ultrasonic transducer circuitry.

Fig. 32.5 **a** ULB tester unit from the top view

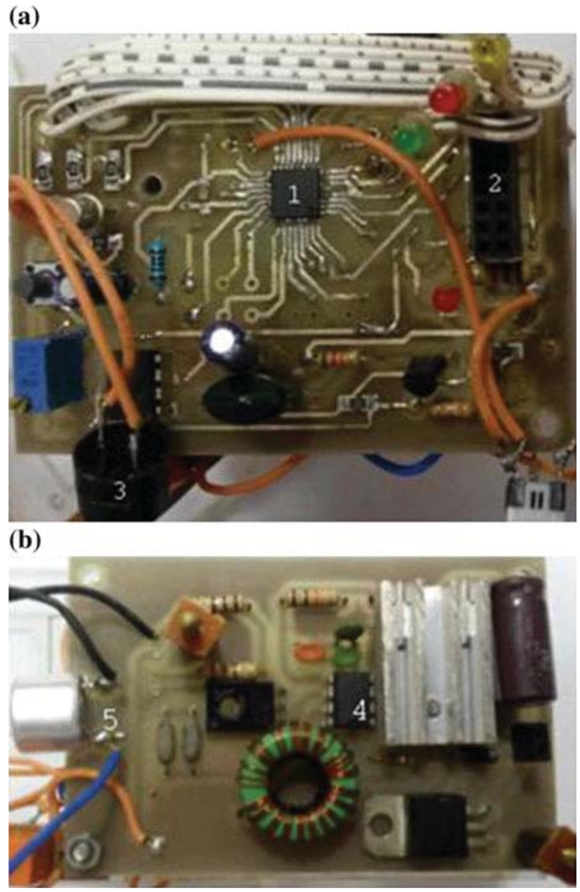

Fig. 32.6 **a** Top circuit board with microcontroller. **b** Bottom circuit board with transducer

Figure 32.6a shows the top circuit board of the tester with marking (1, 2, 3) of the microcontroller, connector to the LCD module, and buzzer. Figure 32.6b shows marking (4, 5) the ultrasonic amplifier and the ultrasonic transducer itself.

32.4 ULB Tester Performance Test

Performance of the tester is conducted in two different prerequisite. The first is the performance of the voltage of the tester as compared to the voltage of the ULB itself. Measurement of the ULB battery voltage uses the internal Analog to Digital Converter of the microcontroller. The resolution of the ADC is 10 bit resulting in voltage differentiation of 0.005 V for a span of 5 V reference which is good enough.

Testing is conducted using different supply voltage with different values and then compared with calibrated voltmeters. Performance of the analog to digital converter of the microcontroller is very similar to that of calibrated voltmeters and therefore simple in comparison. Comparison of voltage between ADC and calibrated voltmeter is very negligible and still within the 0.005 V resolution and the result of the test is displayed on the LCD display to indicate the voltage measured.

Testing the ultrasonic signal is a time domain process instead of frequency domain. First the signal must be captured by the ultrasonic transducer and the result of ultrasonic signal emission by the ULB is shown in Fig. 32.7 which illustrates that the signal will emit for 10 ms every 1 s. Testing of the ULB tester involves changing/sweeping the frequency of the ultrasonic signal from 32.5 kHz up top 42.5 kHz. The result of the ULB tester can indicate that it can detect the signal from 36.5 kHz up to 38.5 kHz and provide message that the signal is good. When the signal is outside the range, then the ULB tester must indicate that the ULB is not in good condition because emitted ultrasonic signal is outside the range. During the ULB test period, the number of pulses within 10 ms is counted and the number must be between 365 and 385 counts.

After the conclusion of the test (battery voltage test and ultrasonic generation test), a test result will be displayed on the LCD, color LED indicator and audio beep as indicated in Table 32.1.

Before the ULB test is conducted by the tester, the tester will perform a rigorous self-test (internal battery test, ultrasonic detection and visual/audio test. When one of the test fails, than the tester will lit a red LED and sound three beeps.

Fig. 32.7 Ultrasonic signal emitted by the ULB captured by the ultrasonic transducer

Table 32.1 Audio and visual feedback of the ULB test

Battery voltage	Ultrasonic signal count	LCD row 1	LCD row 2	LED	Audio beep
2.80–2.97	365–385	Voltage	GOOD	Green LED	1 beep
2.80–2.97	<365, > 385	Voltage	Bad	Yellow LED	2 beeps
<2.80	X	Voltage	Bad	Yellow LED	2 beeps

32.5 Conclusion

A ULB tester with more comprehensive result has been designed and built. The tester will test the voltage of the lithium battery and also the emission of the ultrasonic signal with frequency ranging between 36.5 and 38.5 kHz. More important the device designed and built is very compact and also the very easy to use—by pressing the ULB into the slot of the tester—and the result will be displayed on the LCD, LED indicator and also audio beep.

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