The below identified patent application is available for licensing. Requests for information should be addressed to:

PATENT COUNSEL
NAVAL UNDERSEA WARFARE CENTER
1176 HOWELL ST.
CODE 000C, BLDG. 112T
NEWPORT, RI 02841

Serial Number 10/644,574
Filing Date 8/18/03
Inventor Fletcher A. Blackmon

If you have any questions please contact James M. Kasischke, Deputy Counsel, at 401-832-4736.
LASER-BASED ACOUSTO-OPTIC UPLINK COMMUNICATIONS TECHNIQUE

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) FLETCHER A. BLACKMON and (2) LYNN T. ANTONELLI, citizens of the United States of America, employees of the United States Government, (3) LEE E. ESTES and (4) GILBERT FAIN, citizens of the United States of America, and residents of (1) Forestdale, County of Barnstable, Commonwealth of Massachusetts, (2) Cranston, County of Kent, State of Rhode Island, (3) Mattapoisett, County of Plymouth, Commonwealth of Massachusetts, and (4) Freetown, County of Bristol, Commonwealth of Massachusetts, have invented certain new and useful improvements entitled as set forth above of which the following is a specification.

JAMES M. KASISCHKE, ESQ.
Reg. No. 36562
Naval Undersea Warfare Center
Division Newport
Newport, RI 02841-1708
TEL: 401-832-4736
FAX: 401-832-1231
STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a method and an apparatus for performing non-contact acousto-optic uplink communications. More specifically, the present invention relates to a method and an apparatus for enabling communication between a submerged platform and an in-air platform via the transmission and reception of acoustic and optical signals.

(2) Description of Related Prior Art

Traditionally, underwater acoustic telemetry involves all in-water hardware to establish an acoustic communication link. No known method of communications from a submerged platform to an in-air platform exists. Conventionally, submerged platforms such as submarines have to surface to transmit their data to an
in-air platform or remote site. This procedure can be time consuming and inefficient as compared to a non-contact communications scheme.

What is therefore needed is a technique for facilitating the communication of information from an underwater platform to an above-surface platform without establishing a physical link or line of communication between the two.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a method and apparatus for performing a non-contact acousto-optic uplink communication.

In accordance with the present invention, an apparatus for enabling acousto-optic communication comprises an in-water platform emitting an acoustic signal to an acousto-optic interaction zone. An in-air platform transmits a first interrogation laser beam, a portion of the first interrogation laser beam and a reflection of the first interrogation laser beam from the acousto-optic interaction zone. The in-air platform measures the differences between the received beams. A plurality of optical interferences between the portion of the first interrogation laser beam and the received second laser beam are provided as output. A signal converter receives the
plurality of optical interferences and provides an electrical
signal representing the in-water acoustic communication signal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 provides a schematic diagram of the acousto-optic
communication system of the present invention; and
FIG. 2 provides an illustration of the orientation and
implementation of the in-air and in-water platforms of the
present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

This invention provides a non-contact laser-based sensor
acousto-optic communications uplink capability using the
concepts of laser Doppler vibrometry, i.e., optical
interrogation of the air-water interface, to detect velocity
perturbations which provide information on the signal structure
spectrum and time domain signal of the underwater acoustic
waveform.

With reference to FIG. 1 there is illustrated the apparatus
of the present invention. In-water platform 17 transmits an
acoustic telemetry signal 19 to an acousto-optic interaction
zone 21. In a preferred embodiment, in-water platform 17 is a
platform such as a submarine fully submerged in a body of water.
However, in-water platform 17 may be any platform submerged or
partially submerged in water including, but not limited to, sea vessels, submersibles and remote sensing platforms. In a preferred embodiment, the acoustic signal is comprised of a scheme for underwater propagation such as multi-frequency shift keying (MFSK), M-ary phase shift keying (M-PSK), or M-ary quadrature amplitude modulation (M-QAM). In a preferred embodiment, acoustic telemetry signal 19 is provided electrically by a processor 18 to an acoustic projector 20 which projects acoustic telemetry signal 19 into environmental water.

Acoustic telemetry signal 19 is emitted from in-water platform 17 towards acousto-optic interaction zone 21. Acousto-optic interaction zone 21 is contiguous to air-water boundary 27. In FIGS. 1 and 2, the air is indicated as 29 and the water as 31. As such, part of acousto-optic interaction zone 21 consists of an area of the surface boundary between the air 29 and the water 31. The interaction of the acoustic telemetry signal 19 with the acousto-optic interaction zone 21 causes physical perturbations in the air-water, pressure release boundary 27. These perturbations take the form of surface vibrations.

In-air platform 11 transmits an optical interrogation laser beam 25 created by a laser 32 towards the acousto-optic interaction zone 21 at a time when the perturbations in the air-
water boundary 27 formed at the acousto-optic interaction zone
21 are expected. In a preferred embodiment, in-air platform 11
is a rotary winged aircraft capable of hovering over and in
proximity to acousto-optic interaction zone 21 as illustrated in
FIG. 2. While described in relation to a helicopter, the
present invention is not so limited. Rather, the in-air
platform of the present invention is broadly drawn to include
any platform located above the air-water boundary capable of
emitting an interrogation beam 25 including, but not limited to,
fixed wing aircraft, satellites, land based systems, and
portions of a sea vessel located above water.

The interrogation beam 25 is reflected off the air-water
boundary 27 and back to in-air platform 11 for reception as a
received reflection beam 23. Although, in the preferred
embodiment, interrogation beam 25 and reflection beam 23 are
transmitted and received at the same platform, different
platforms could be used for transmitting and receiving. Having
been formed from a reflection off of a surface experiencing
vibrational perturbations, received reflection beam 23 is laser
light altered to include numerous frequency shifts corresponding
to the vibrational perturbations of the acousto-optic
interaction zone 21.

Analysis of the received reflection beam 23 may be
performed to recover acoustic telemetry signal 19 using the
invention as claimed hereinafter. Laser Doppler vibrometry refers to optical interrogations of the pressure release interface and layers slightly below the surface to detect velocity perturbations. A laser doppler vibrometer is joined to single sensor or a number of sensors arranged to obtain beam formable array data. A splitter is used to divide out unperturbed portion of the interrogation beam from the interrogation beam. The unperturbed beam portion is used as a reference to compare with received reflected beam. As noted above, received reflection beam is perturbed by the vibrations in the air-water boundary in contact with acousto-optic interaction zone. The optical interference between the two beams are measured as a Doppler velocity by an interference vibrometer, which is then converted to an electrical representation of the acoustic signal in the form of an electrical signal by acoustic/photonic/electrical signal converter. Acoustic/photonic/electrical signal converter outputs the electrical signal to a telemetry receiver. Telemetry receiver demodulates or otherwise decodes the electrical signal to recreate the received acoustic telemetry signal at the air-water interface.

Because the perturbations to the acousto-optic interaction zone occur over a finite time and space, advance knowledge of the time and place to emit and receive optical interrogation
beams is generally required by the in-air platform 11. This
required knowledge adds a layer of data transmission security,
preventing unwanted parties from accessing the acoustic
telemetry signals 19. In addition, the sensing capability of
the present invention can be used for a number of related
applications such as threat/marine mammal detection.

It is apparent that there has been provided in accordance
with the present invention an apparatus for performing a non-
contact acousto-optic uplink communications which fully
satisfies the objects, means, and advantages set forth
previously herein. While the present invention has been
described in the context of specific embodiments thereof, other
alternatives, modifications, and variations will become apparent
to those skilled in the art having read the foregoing
description. Accordingly, it is intended to embrace those
alternatives, modifications, and variations as fall within the
broad scope of the appended claims.
LASER-BASED ACOUSTO-OPTIC UPLINK COMMUNICATIONS TECHNIQUE

ABSTRACT OF THE DISCLOSURE

An apparatus for enabling acousto-optic communication comprising an in-water platform comprising means for emitting an acoustic signal to an acousto-optic interaction zone, an in-air platform comprising the ability for transmitting a first optical interrogation beam, the ability for receiving a portion of the first interrogation beam and a second laser beam formed from the reflection of the first interrogation beam off of the acousto-optic interaction zone, the ability for measuring and outputting a plurality of optical interferences between the portion of the first interrogation beam and the second reflected beam, and a signal converter receiving as input the plurality of optical interferences and outputting an electrical signal representing the received acoustic telemetry signal at the interrogation point at the air-water interface.
FIG. 1