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ULTRASONIC TECHNOLOGY APPLICATION FOR THE SAFETY ASSURANCE OF THE LIFTING OPERATIONS AT SEA

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The purpose of this development is the system engineering that will track the cargo position lowering by the crane relatively the deck of the receiving ship. Used in the development the ultrasonic sensors perform the main role for the assigned mission solution. The functional scheme of the setup with the description of various cargo-carrying electric drives testing system control is presented. General movements (rolling, pitching, heaving) of the ship as solid body is described. The system comprising the Arduino microcontroller, ultrasonic sensors and ZigBEE technology wireless module is shown. The configurations «point-to-point» is selected as the network topology. The possibility of the XBee modules firmware (acting on the ZigBEE technology), with the XCTU software is presented. The choice of the control system for the ultrasonic sensors as the alarm installation for the crane operators is proved, which allows increase the safety of the lifting operations at sea.

Keywords: Ultrasonic sensors, electric drive, cargo position, track system, wireless

1. Introduction

For transfer of people and all kinds of cargo from one ship to another, or to any offshore structures (drilling oil derrick, surface pier or underwater construction, etc.), port, floating and shipboard crane devices are used. Besides these cargo operations, it is often necessary to keep unchanged the position of the cargo being underwater and suspended to the ship (for example, when operated at the equipment for the research investigation, movie cameras and other objects).

To perform these operations in terms of sea disturbance the crane devices of the ships and marine structures, except units and mechanisms native to the general duty lifting apparatus are equipped with the following units and mechanisms: directing devices that reduce the load swinging and ensure the close fit of the cargo to the specific location on the deck of the receiving ship; tracking mechanisms that ensure the constant lifting and lowering speed of the cargo with respect to the deck of the receiving ship

Most types of conventional handling equipment can be used as the crane devices, and with choosing the type of machine it is necessary to take into account the nature and properties of the transferable cargo, the rated capacity, direction and path length of the cargo transfer, stowage methods in the initial and final positions, etc.

For the transshipment, requiring particularly careful handling, the cargo fluent introduction (excretion) mechanism keeping track of the receiving ship is used in the crane devices to prevent significant accelerations and impact stress introducing in the tracking mode.

The operation of the cargo transfer device occurs under conditions of the dynamic effects caused by the necessity to adjust the speed of the lowering cargo depending on the motions. Therefore, in the design of such device it is essential to focus on the additional inertial forces, which are the consequence of the motions and can reach relatively large quantities.

2. Design of the experimental system

Motions on the regular excitement are its own (free) solid body vibration, which movements are accompanied by the appearance of the efforts proportional to the magnitude of these movements seeking to return it to the balance original position.

The given conditions, i.e. the solid body flexing coupling reaction are represented in this case as the additional force of the structure buoyance resulting from the changing of the drowned volume size or shape. From this viewpoint, the ship is the solid body with three degrees of freedom, having therefore the same number of the main natural motions, namely:

- rolling (oscillatory) motions, i.e. the oscillatory spin around the roll axis;
- pitching motions, i.e. the oscillatory spin around the pitch axis;
- heaving motions, i.e. oscillatory displacement in the vertical direction.

The other three possible displacements of the ship as the solid body, i.e. its turn around the vertical axis, and two displacements in the horizontal direction can't have the character of the oscillatory motion, as they are not accompanied by the changes in the size or shape of the underwater structure volume.

The experimental setup under development is needed to assess the desirability and feasibility of the project execution on the application of the ultrasonic distance sensors on being lifting mechanisms [1].

Graphically analogous system is shown in Fig. 1

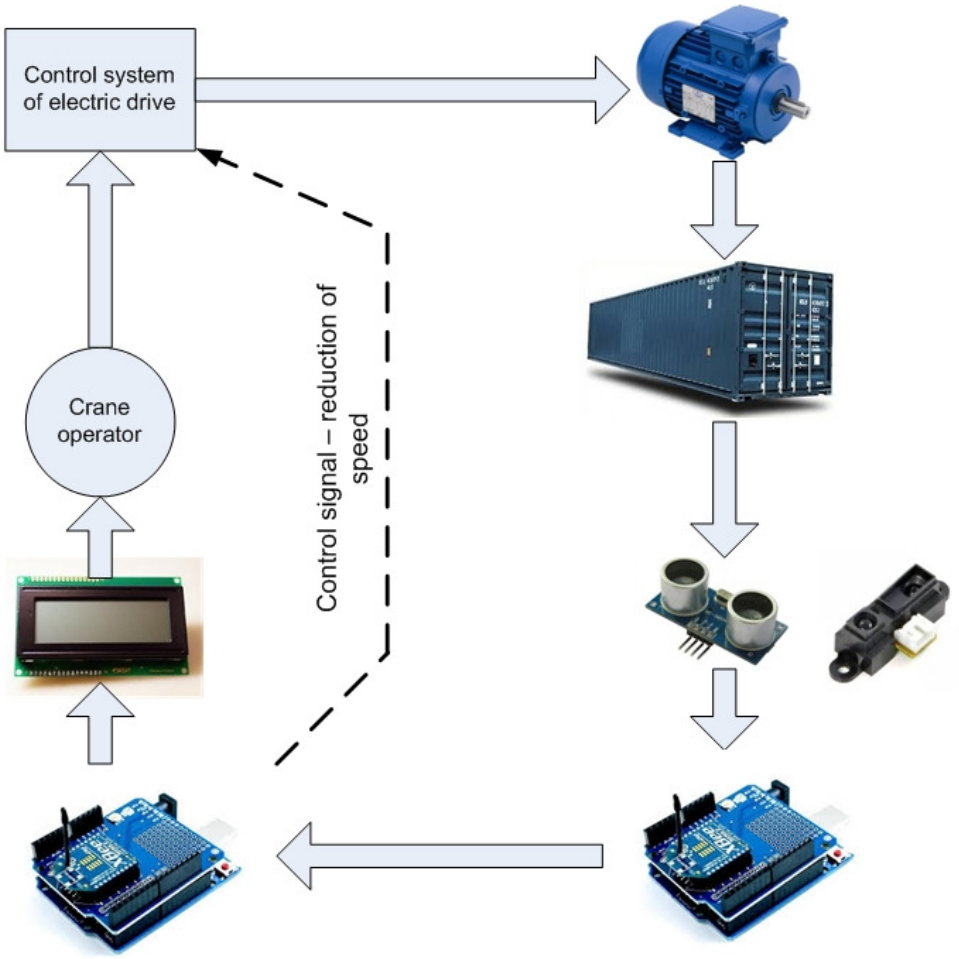

Fig. 1 Scheme of the experimental complex under development

In our case, the demand signal to the lowering cargo is set by the crane operator. Through the control system the electric motor starts spinning away the drum, lowering

(raising) the cargo. The ultrasonic sensors located at the cargo itself, or at the fixing elements (hooks), using the microcontroller and wireless XBee module set the signal to the wireless module of the coordinator. Through the screen located at the cab, the information about the distance to ship's deck is transmitted, which moves the cargo and light alarm comes into action. Also getting information from the ultrasonic sensors one may adjust the lowering rate limit due to the approach to the deck. It is the technological solution which will be discussed further in the installation process.

3. Parts of the prototype

The experimental setup of the cargo transfer implementation to the shaking platform.

1. Arduino microcontroller
2. Ultrasonic ranging module HS-SR04
3. Wireless modules ZigBEE

First of all it is necessary to mention a few words about the Arduino controller, which is the basis of the experimental setup. The microcontroller on board is programmed using the Arduino language (based on the Wiring language) and the Arduino framework (based on Processing medium). Device projects based on the Arduino, can work independently, or interact with the software on the computer (e.g.: Flash, Processing, MaxMSP). [2]

Consider the ultrasonic ranging module HS-SR04. Fig. 2

Fig. 2 Physical form of the ultrasonic sensor HC-SR04

HC-SR04 is the transmitter and receiver of the ultrasonic signal placed on one board. Speaker and microphone, in fact, are only for ultrasound inaudible to the human ear. Except the transmitter and receiver the necessary piping is also on board.

The principle of the sensor operation is very simple: when the microcontroller reports it would be necessary to obtain the data, the sensor generates the ultrasonic signal and starts to «listen». When the signal reflected of an object is returned to the sensor HC-SR04 sends the logical unit to the microcontroller and further the controller starts its work. [3] The idea is that one can measure the time during which the signal is back, and then with the help of the simple calculations to get the distance. Here the scheme of the sensor connection (Figure 3):

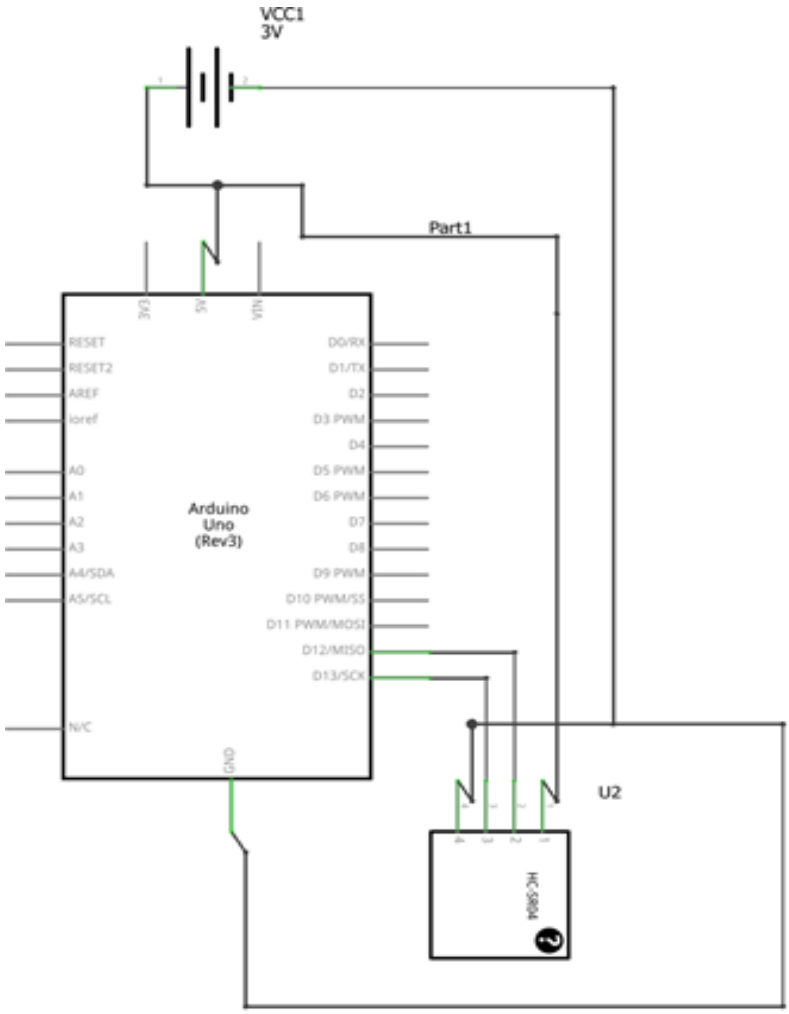

Fig. 3 Scheme of the distance sensor connection HC-SR04

Thus, the data received from this sensor will be perceived by the Arduino microcontroller as the series of numbers. Further, it is necessary to convert the signal to the wireless, and pass it on the Arduino located at the crane cab, the display (indicating the distance to the ship's deck), as well as to the light alarm actuation.

4. Wireless technology ZigBEE

For this purpose use the wireless modules XBee, which are based on the ZigBee 802.15.4 technology. The wireless networks based on IEEE 802.15.4 are the alternative ones to wired connections in the distributed systems of monitoring and control, and are characterized by the flexible design, demand lower costs in their installation and operation.

ZigBee supports the variety of the network configurations and allows combine the devices according to the following topologies: «Point-to-Point», «star network», «cluster tree» and «multicellular network». The stack network functions provide network scanning to detect active channels, device identification on the active channels, network creation on the unused channels and interconnection with the existing network in the area of the personal wireless network, recognition of the supported services according to the specific device profiles, routing function. According to this fact the devices can automatically log into the network and exit it, the undesirable consequences «failure at one point» are eliminated due to the presence of multiple routes in the each node. Fig. 4 represents the different variants of the ZigBee network topologies.

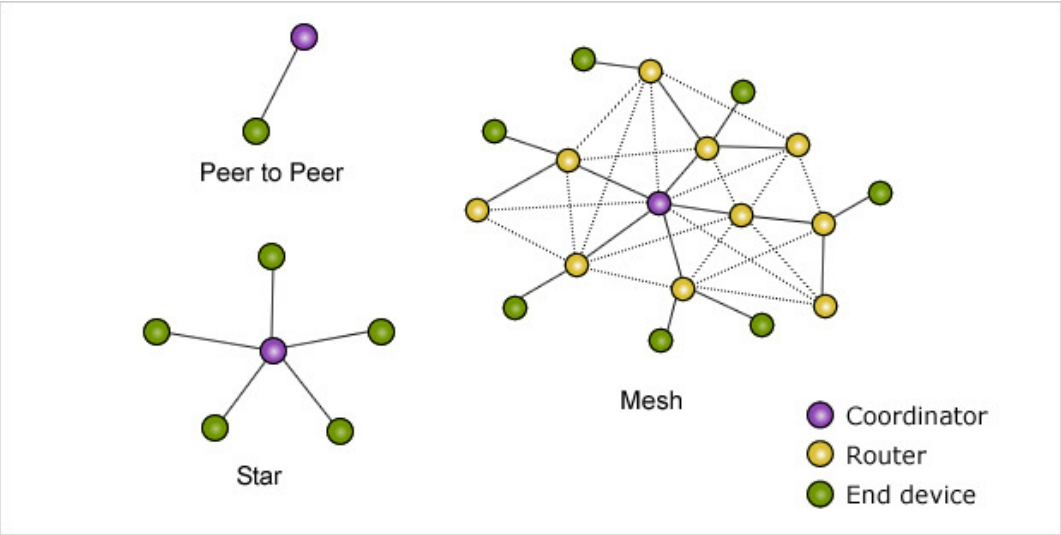

Fig. 4 Various ZigBee/802.15.4 network topologies

First of all configure the wireless module that will send the signal to the microcontroller with the ultrasonic ranging module. For this we need the ZigBee (Xbee) module, SparkFun controller for its firmware, and also the expanding board for the Arduino (Xbee Shield).

In order to have the opportunity to download the firmware (code) on the wireless module (it will act as the coordinator), it is necessary to install the software XCTU on the computer.

Configure the wireless signal between the ultrasonic ranging module connected to the Arduino Coordinator and End Device receiver.

To implement this scheme we will need:

1. Module 2 XBee Series. Exactly the same Pro-version is appropriate
2. Arduino Uno
3. IO Shield
4. XBee-USB adapter

Also it must be borne in mind that it is impossible to change the XBee module role by the simple command. Each role has its own firmware that it is essential to download it. This is similar to the process of the Arduino firmware by the sketch, the only difference is that the other tools are using, and the sketch itself has been compiled by the manufacturer.

Use the X-CTU program for the firmware. First of all make the module firmware with the ultrasound sensor. Set it to USB-Serial adapter and using mini-USB cable, connect the adapter to the computer. Module working with the distance sensor, must take firmware as the End Device, and the Arduino being in the crane cab, coupled with the screen and light alarm, respectively as the Coordinator.

Further we have to program the microcontroller coordinator, during signal receiving from the ultrasonic sensor about approaching to the ship's deck (platform), the signal is set to the light alarm, connected as follows (Figure 5):

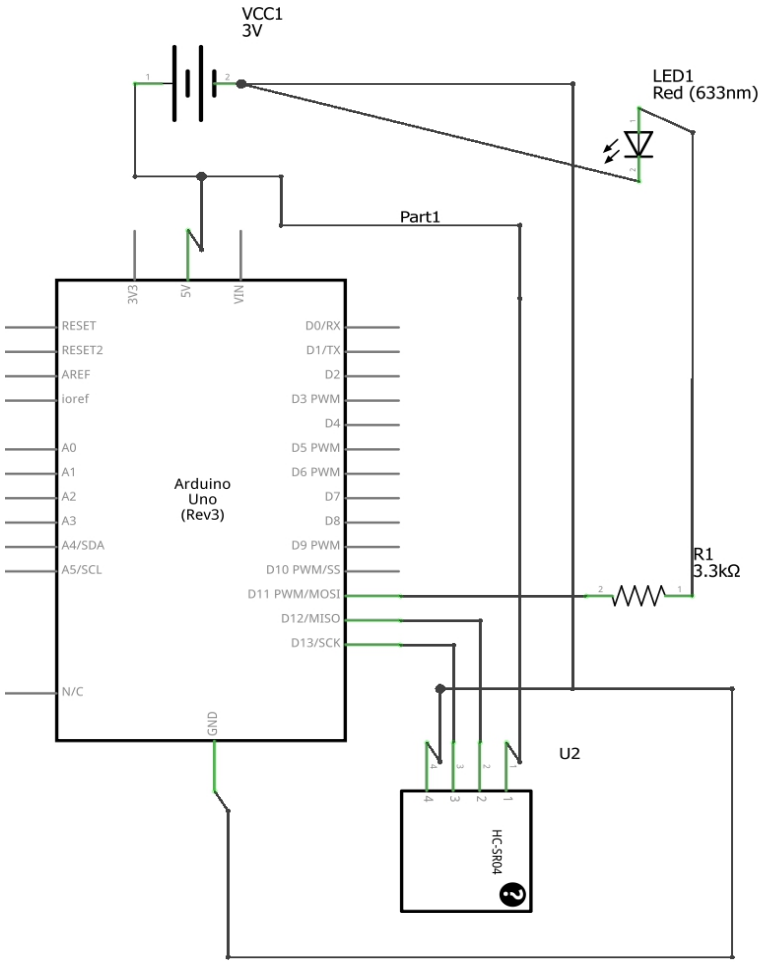

Fig. 5 LED connection functional scheme as the signaling lamp

5. Conclusion

As a result, we obtain installation to determine the distance to the ship's deck during cargo operations, as well as the alarm system that will warn the crane driver of the distance reduction from the cargo to the deck [4]. Especially it is important during the transfer of people and valuable cargo. Considering the wireless nature of the system, and also the possibility to install several microcontrollers as the End Devices, it is possible to send the signal in the log or on the screen, installed at the supervisor on the platform, or the engineer on labor protection. In general, this system allows not only protect the process of cargo raising and lowering from the shaking platform (ship's deck), but permits to the rest of the staff involved in the operation to evaluate the work of the crane operator, looking after the log records of the transactions.

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