

## ZigBee Sensor Network for controlling the lightening system

**Abstract.** A control system for an HID (High Intensity Discharge) lamp with the magnetic ballast is considered. Electronic switch unit driven by ZigBee system controls illumination of lamps in network. RF ZigBee transceivers are employed to turn the HID lamps on and off and to control illumination through wireless remote communications. Thereby are achieved considerable energy saving. Also operational status of the ballast and HID lamp can be controlled by the sensors and all failures will be automatically detected and notified to users.

**Streszczenie.** Niniejsza praca ma na celu przedstawienie zastosowania sieci sensorycznej Zigbee, dla sterowania lampami HID, wykorzystywanymi w miejskich ciągach komunikacyjnych. Wykorzystano tu system zaimplementowany na 16-bitowym mikrokontrolerze PIC24HJ256GP610. Sterowanie intensywnością świecenia lamp HID jest realizowane bezprzewodowo w oparciu o łącznik zintegrowany z obciążeniem lampy HID. (Wykorzystanie interfejsu ZigBee do sterowania oświetleniem ulicznym)

**Keywords:** HID lamp; ballast; Zigbee network, PIC microcontroller; Xbee module  
**Słowa kluczowe:** sieci sensoryczne ZigBee, PIC mikrokontroler, moduł Xbee.

### Introduction

The subject of the paper is magnetic ballast control system for HID lamp using Zigbee. Further is proposed a model, that comprises: a management system module for outputting HID lamp control signals on the basis of Zigbee communications, a wireless control module with Zigbee unit, MCU, power supply unit, an electronic switch unit for controlling illumination and RF transceiver and a magnetic ballast for the HID lamp. Schematic diagram of the system is shown in fig. 1.

An HID (high intensity discharge) lamp is a lamp, in which high pressure xenon gas and metallic compounds in arc tube are excitedly discharged and generate white light close to natural, since the xenon gas suppresses neighboring ultraviolet rays and electromagnetic waves. The HID lamp, such as a metal halide lamp, high pressure sodium lamp, high pressure mercury lamp and the like, is lit by a specially designed ballast (magnetic or electronic) and a starter that generates instant high pressure.

Because a certain area receives a plenty of sunlight in daytime and does not need lighting in that time, whereas another areas do need, illumination of lamp should be controlled, in order to save energy or to create specific atmosphere needed. The magnetic ballast control system controls illuminations and easily grasps operation and failure status of the lamp (through current sensor).

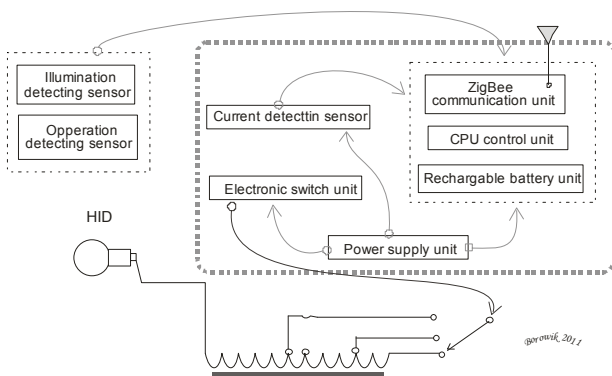


Fig.1. Schematic diagram of the wireless control module system

The control system for a HID lamp has a low-priced magnetic ballast, an electronic switch unit for controlling illumination and RF transmitting and receiving means that use the ZigBee based frequency, so that turning on and off and illumination of the HID lamp can be remotely controlled.

Each lamp has its own wireless control module with Zigbee module, CPU, application board with sensors, power supply, electronic switch unit and ballast unit. Dispatcher of all lamps sends from his office wirelessly signals to particular lamps and receives feedback. In addition, the module can be controlled through a gateway through a Zigbee wireless network.

The Zigbee technique [2] is a standard specification based on IEEE 802.15.4. It has a low transmission speed and can remotely control a variety of equipment. The Zigbee PHY layer uses a frequency bandwidth of 2.4 GHz and 868/915 MHz, direct sequence spread Spectrum (DSSS) modem and MAC of CSMA/CA. With a communication distance of 100 to 500 meters it consumes less power, than 500  $\mu$ W.

As author states, it is appreciated, that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the invention.

### Description Of The Modules

In this paper we propose detailed solution of particular modules. As CPU in the lamp control module the Microchip PIC 24HJ256GP610 microcontroller [3] is used. It has following tasks:

- acquiring data from the current detecting sensor of the HID lamp, thus detecting, if the lamp is not broken,
- receiving signals from dispatcher or from internet through gateway and the Zigbee wireless network,
- processing received signals
- dimming lamp lightening and turning lamp on and off through generating appropriate signals to electronic switch unit and subsequently to the magnetic ballast unit (see figure)
- sending feedback to the remote management module through Zigbee RF transceiver.

The PIC 24HJ256GP610 microcontroller is well suited to acquiring analog data from sensor, because is equipped in several inherent ADC modules. We used the ADC module with the 10-bit resolution. After selecting port line for analog input we prepared in C language [6] the functions for initializing and configuring ADC module and for acquiring and converting data from the analog input [7]:

```
// initialize the ADC for single conversion, select Analog input pins
void initADC( int amask)
{
    AD1PCFGH = 0xFFFF;
    AD1PCFGL = amask; // select analog input pins
    AD1CON1 = 0x00E0; // auto convert after end of sampling
    AD1CHS0 = 1; // select analog input channel
    AD1CSSH = 0; // no scanning required
    AD1CSSL = 0;
```

```

AD1CON3 = 0x1F02; // max sample time = 31Tad, Tad = 2 x Tcy =
125ns >75ns
AD1CON2 = 0; // use MUXA, AVss and AVdd are used as Vref+/-
AD1CON1bits.ADON = 1; // turn on the ADC
} //initADC

//-----
unsigned long readADC( int ch)
{
    AD1CON1bits.SAMP = 1; // start sampling, automatic conversion will
follow
    while (!AD1CON1bits.DONE); // wait to complete the
conversion
    return (long) ADC1BUF0; // read the conversion result
} // readADC

```

If the changes in the current are substantive, the failure of the magnetic ballast or the HID lamp is assumed.

As Zigbee units we used the DIGI International Xbee modules [4] [5]. They can operate in the API programmed mode, which is convenient in our case. It is the frames mode. To UART of the Xbee module the frames of selected type, containing payload with data to remote Xbee modules are sent from microcontroller as well as are requested and received informations from the dispatcher. Used frame types are shown in the Table 1.:

Table 1. API frame types.

API ID	API FRAME NAMES
0x10	ZigBee Transmit Request
0x17	Remote Command Request
0x8B	ZigBee Transmit Status
0x90	ZigBee Receive Packet (AO=0)
0x97	Remote Command Response

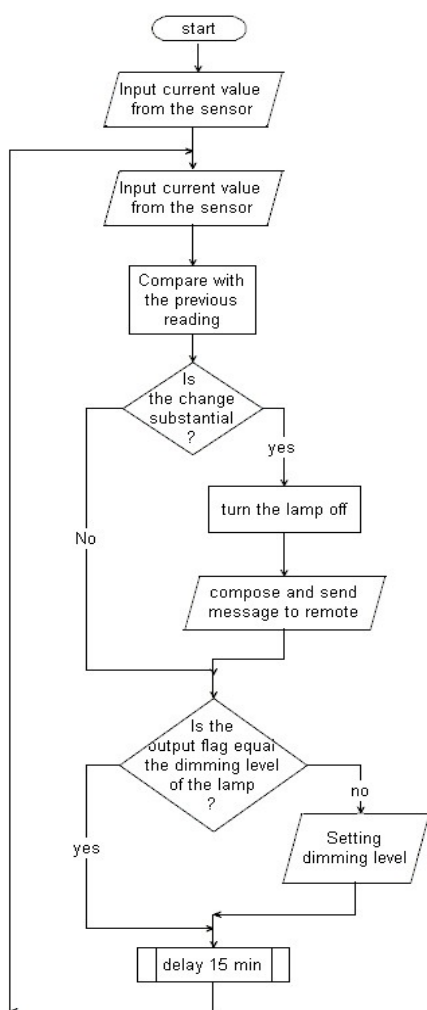


Fig. 2. Flowchart of the firmware permanent loop

### Illumination control:

Illumination is controlled by setting one of four values for the light outputted: 100%, 80%, 70% and 50%. It is accomplished in the electronic switch unit by providing condensers directly connected to the HID lamp. When condensers 10, 3 and 2 μF are used, the following output values can be obtained:

Table 2. Lightening Output For Different Condensers

Operation	10 μF	3 μF	2 μF	Total capacitance
Turn on Output 100 %	Used	Used	Used	15 μF
Output 80 %	Used	Used	Unused	13 μF
Output 70 %	Used	Unused	Used	12 μF
Output 50 %	Used	Unused	Unused	10 μF
Turn of	Unused	Unused	Unused	0

The dispatcher decides what dimming to apply to the lamp and sends appropriate information to the wireless control module. The information is received by the PIC microcontroller from remote in the interrupt service routine and the value for the output flag is set.

After configuring and initializing microcontroller, the permanent loop is executed on the basis of the time interval of 25 min performing all necessary actions:

- checking the current value from the sensor and comparing with the previous reading
- if substantial changes in the reading are detected, the signal is generated, that cuts off power of the failed lamp
- checking the value of the output flag and comparing with the dimming level of the HID lamp. If the values differ, setting the new value to the lamp lightening through generating signal to the electronic switch unit.

The above actions can be schematically presented on the diagram (Figure 2).

### Conclusions

The presented model takes into account the digital control system for dimming level of the HID lamp. The model has been applied to analyze experimental lighting control. Typical data flow from the gateway out to devices in the network is intermittent based device, using ZigBee network. In our design contains an integrated lighting controller based on an embedded system, interface circuits and ZigBee communication. The produced data shows expected reliability for a distributed ZigBee network in a commercial environment. The particular environment is typical for many ZigBee commercial uses and provides a good indicator of expected operation. These networks experience little to no message loss over time indicating a robust and reliable system.

### REFERENCES

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