A CCD CAMERA WITH WIRELESS INTERFACE

Tomáš Hynčica

Doctoral Degree Programme (1), FEEC BUT

E-mail: xhynci02@stud.feec.vutbr.cz

Supervised by: Václav Jirsík

E-mail: jirsik@feec.vutbr.cz

Abstract: This work deals with the problem of wireless transfer of visual information from a CCD camera. A camera system, both hardware and software is designed and realized. The wireless communication is based on the IEEE 802.15.4.

Keywords: CCD camera, IEEE 802.15.4, wireless communication, serial memory, switched-mode power supply

1. INTRODUCTION

The article describes a design of software and hardware for a wireless data transfer from the CCD camera. The camera system consists of a transmitter, a receiver and PC with control program and a user interface. As the receiver existing equipment is used, the transmitter is designed and manufactured during this work so as the software for all components. The created camera system is used for a remote acquisition of images. It can by used, for example, in these applications:

- Security systems – scanning when a door is opened, motion in the monitored area or periodical check of an area.
- Monitoring - checking the condition of a monitored area or object, for example control of fuel level.
- Remote reading - periodical readings of the inaccessible meters (water meters, gas or electricity).

2. THE CAMERA SYSTEM

As was mentioned earlier, the camera system consists of tree main parts: a transmitter (a service module for the camera, an end device), a receiver (a coordinator) and PC with necessary software. Control of the entire system, image storage and its display performs the control program running on PC. The service module is equipped with a radio interface. It provides control of the CCD camera, illumination of a scene, saving up to four images into a serial memory, repeated scanning and sending images on the basis of inputs from connected external sensors. It communicates with the coordinator via a wireless interface and the coordinator is connected to PC via a serial line (see block diagram on Figure 1). The network topology is a star, system consists of one coordinator and one to four end devices. The basic description of hardware is in chapter 3 and software is described in chapter 4.

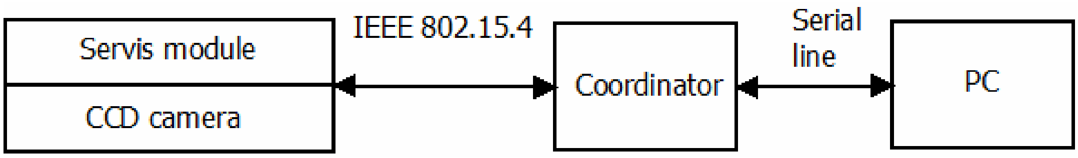

Figure 1: The camera system

2.1. BASIC DESCRIPTION OF CCD CAMERA

Used camera is a type C328R manufactured by COMedia company [1]. The camera module has small dimensions (20 mm x 28 mm), see Figure 2. The camera uses a color sensor which allows a resolution up to 640x480 pixels when using JPEG format. DC voltage of 3.3 V is needed for powering the camera.

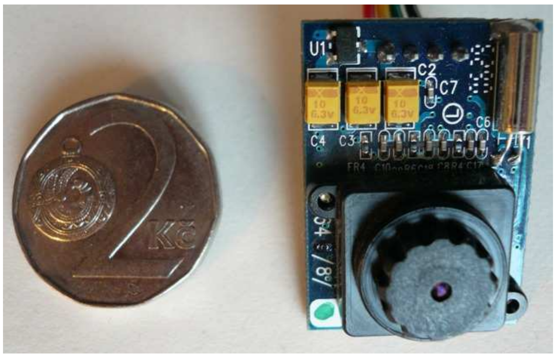

Figure 2: The camera module

2.2. WIRELESS INTERFACE

Wireless data transmission is realized using the radio interface according to IEEE 802.15.4 standard [2], [3]. Hardware implementation is based on Freescale radios [4]. IEEE 802.15.4 is a new international communication standard (November 2004) for small-scale network (PAN - Personal Area Networks) and for small distances, the range is usually called as 30 m indoors and 70-100 m in free space. It is designed for low power devices that do not have high demands on the transmission speed (at 2.4 GHz, the maximum speed is 250 kbps). The standard defines the physical and the access layer protocol (PHY and MAC), which uses the ZigBee protocol. It operates in unlicensed frequency bands.

Usage is primarily for industrial applications, building automation and consumer electronics. The main advantages are reliability, easy implementation, very low power consumption and low cost. IEEE 802.15.4 divides the devices according to level of provided services to devices which implement the complete protocol framework (FFD - Full Function Device) and a devices that implement only necessary functions (RFD - Reduced Functionality Device).

3. HARDWARE DESIGN FOR THE SERVICE MODULE

The hardware design is based on requirements for the service module. It must get an image, format it, compressed it and split it into packets, which can by sent via the wireless interface. It must also provide the transfer of image data from the camera, save them to the memory and send them to the coordinator. It must also provide adequate illumination of a scanned scene. The service module also allows a connection of external sensors to expand possible uses and connection to other devices via the serial line (at 3.3 V level). The module is powered by DC voltage between and can operate on batteries.

3.1. OVERALL STRUCTURE AND MAIN PARTS

Overall structure is shown on Figure 3. Wiring and a printed circuit board have been designed in Eagle 4.16r2 Light. The main parts of the service module are:

- Modem PAN 4551 (Panasonic)
- Serial memory AT45DB011B
- Switched-mode power supply

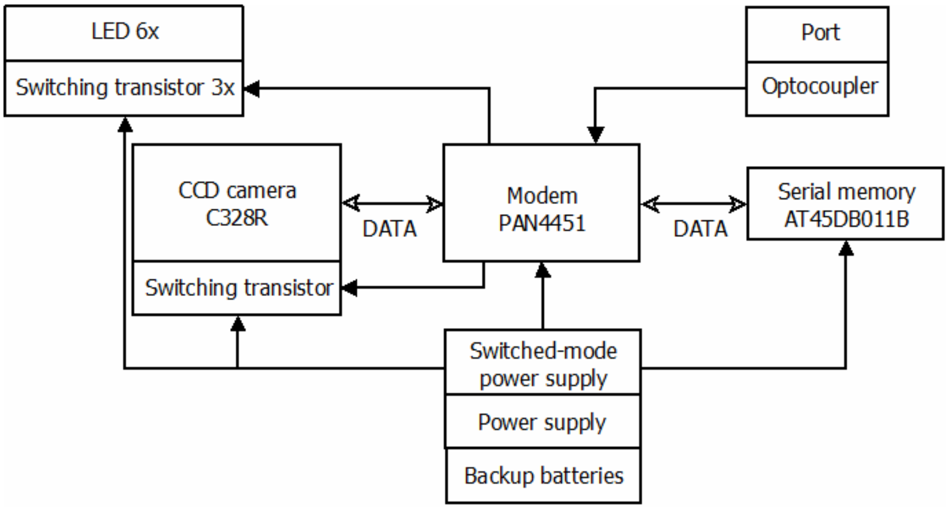

Figure 3: Overall structure of the service module

3.2. SWITCHED-MODE POWER SUPPLY

The power supply design is based on a monolithic control circuit MC34063A, see Figure 4. Required output voltage of the power supply is 3.3V (memory and wireless module may have a lower power, but the camera module requires optimal supply as 3.3V). The values of some passive components (resistors, capacitors) can be read from the datasheet, the rest (value of the induction of a coil and a voltage divider) has to be calculated.

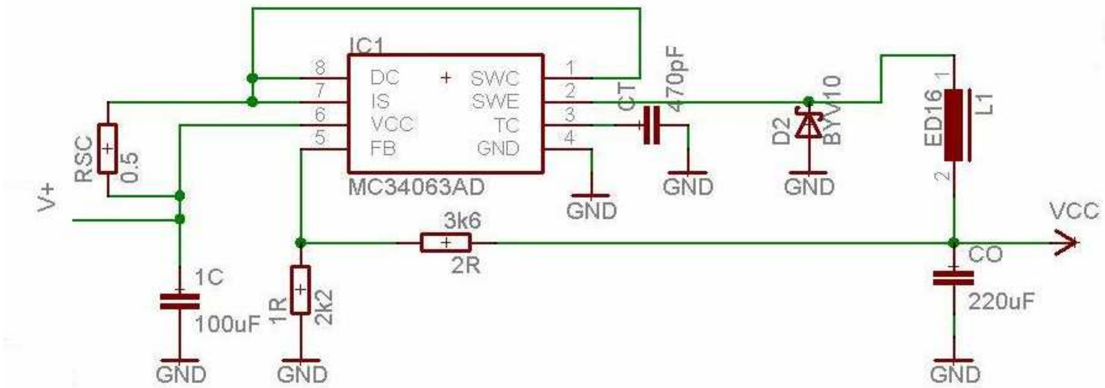

Figure 4: Design of the switched-mode power supply

4. SOFTWARE FOR THE CAMERA SYSTEM

All tree main components of the system (the service module for the camera, the coordinator and PC) require software for their proper function. Applications for the coordinator and the service module are developed in CodeWarrior, the control application is developed in MS Visual C++ 2008 Express Edition.

4.1. SOFTWARE FOR THE SERVICE MODULE

Application is responsible for operating the service module. In the wireless network service module operates as the terminal device (RFD). Provides turning on and off the camera module, establishing communications, a camera setup, a scene illumination, image storage and sending it to the coordinator. The service module is primarily controlled through messages sent by the coordinator. These messages are data packets size of two bytes where the first determines the type of a command and the other is additional information. It is also possible to start scanning from input of external sensors attached to the service module. Service module also sends error messages and other information to the coordinator.

An important part of the module is the serial memory. The memory is used to store up to four images for their possible reuse. For each image a fixed data space is reserved. Images are stored such way, that four recent photos are stored (always the oldest image is overwritten). Images from the memory can by load and sent on a demand. It is also possible to delete any image. For work with the memory is necessary to firstly upload control data in it. Then is possible to either read or write data into it. For easy work with the serial memory a library is developed. Functions in the library are divided into three groups (for read, for write and auxiliary).

4.2. SOFTWARE FOR THE COORDINATOR

The coordinator provides communication between PC and the service module. To PC is connected via a serial interface, with the service module communicates using the wireless protocol IEEE 802.15.4. The coordinator receives commands from the control program via serial line, determines what type of a command it is and then sends the appropriate message to the service module. The coordinator also has to control the radio communication, receive data packets from the service module, request for resending of any lost or corrupted packets and so on.

4.3. CONTROL PROGRAM

Program is developed in language C++ and run under OS Windows XP. It is a user interface and provides control of the whole camera system. Also it is responsible for receiving of data packets, their joining into one file – the image. Further it stores and displays images. The control program distinguishes three types of data packets: error messages, info messages and data packets. Each type has to be handled in a different way.

5. RESULTS

In first part, wireless data transmission is evaluated, in particular the dependence between packages sizes and transmission speed. In the second part, the camera and images are evaluated.

5.1. WIRELESS DATA TRANSMISSION

A dependency of transmission speed on the size of a data packet is measured. A fixed amount of data (3 000 000 B) is being sent from the service module (end device) to the coordinator. From these data a bit rate is calculated for each packet size. For measurements are used Freescale radios [4]. The measurement is performed in a brick family house and the end device and the coordinator are located in adjacent floors. When the end device is placed out of the house (the coordinator remains inside) a significant deterioration of the signal occurs and transmission is possible only in some places.

The coordinator was connected to PC via a serial line. For the measurement a specific application is created. For every size of data packets is the measurement performed five times and then a mean value of a bit rate is calculated. The measurements suggest that the larger data packet is used, the higher is the bit rate, see Table 1.

5.2. THE CAMERA

Image is obtained 3 seconds after the request for scanning (one second it takes to establish communication and initialization, two seconds takes the camera to adjust to light conditions). Follow data transmission depends on the size of the image, such as total time to scan and transfer an image size of 15 kB is about 15 s.

Package size[B]	Time [s]	Bit rate [kb/s]
20	871	27,5
40	480	50,1
60	358	67,3
80	286	83,9
100	247	97,1

Table 1: Mean values (success of about 98%)

The size of the scanned images depends on what is on the image. Whole black or white image has size about 7 kb, multicolored and structured image size is about 31 kB. Size of an image capturing an object on the background is around 15 kB.

Testing show that the illumination is effective only for nearby objects (up to 1.5 meters). For illuminating of distant objects or scenes, such as cars on a street, an external light is needed. Also when installing the camera for the first time it is necessary to focus it manually.

6. CONCLUSION

During the work the camera system with the wireless interface is designed and implemented. The work and communication with the CCD camera is tested. Based on that, hardware and software for the service module for the camera is designed and implemented. Also software for the rest of the system (PC and the coordinator) is developed.

As part of the solution the test program is create to evaluate the transmission properties of the radio communication. The dependency of the bit rate of the radio interface on the size of data packets is discussed. The bit rate increases with increasing of data packets size. After testing the camera the evaluation of its characteristics is presented, as well as evaluation of images sizes in dependency on the character of the scanned scene.

The result of this work is the complete system that realizes wireless transfer of images from the CCD camera. The system can be further improved by modification for possible operation on batteries, indoor and outdoor use or use of more powerful lights for suitable illumination of more distant objects.

ACKNOWLEDGEMENT

This work was supported by grant "Modern Methods and Approaches in Automation" from the Internal Grant Agency of Brno University of Technology (grant No. FEKT-S-10-12).

REFERENCES

[1] Datasheet C328R, Available at: http://www.comedia.com, 2009

[2] IEEE 802.15.4 [online]: IEEE 802.15 Working Group for Wireless Personal Area Networks (WPANs). Available at WWW: http://www.ieee802.org/15/, 2011

[3] Bradáč, Z., Fiedler, P., Hynčica, O., Bradáč, F.:Bezdrátový komunikační standard ZigBee, Automatizace, vol.4, pp. 261 - 263, 2005

[4] Welcome to Freescale Semiconductor [online], Available at WWW: http://cache.freescale.com/files/rf_if/doc/ref_manual/ZHDCRM.pdf?fsrch=1&sr=23, 2009