CPLD Implementation of low Power Multi Serial to Ethernet Gateway for UAV Data Acquisition Systems by Using PIC

Revanasiddappa B, K. V. Ramana Reddy

Abstract— An Unmanned Aerial Vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot on board. It's a flight controlled under the remote of a pilot on the ground. Historically, UAVs were simple remotely controlled aircraft, but day-to-day autonomous control is rapidly being employed.

The development of autonomy technology makes UAV to combining information from different sensors like temperature sensor and humidity sensor. The collected information communicated to pc. With the help of camera motion planning determines an optimal path for vehicle to go while meeting certain objectives and constraints.

CPLD's flexible programming features also allow further upgrade for system. Low power, as the multi card solution can come in single CPLD card with smaller modules around it communicating local area number of systems transferring the data from one system to another system. In this project all the components which are using they required maximum 3.3V power supply instead of 5V.

Index Terms— Ethernet, PIC, CPLD, UAV, UART, Gateway, Multi serial.

I. INTRODUCTION

The data's are sending to the PIC microcontroller which are acquired from environment and are transmitted to the Ethernet module with the help of zigbee transceiver, and is send to pc, by the TCP/IP protocol. The Gateway [2] consists of CPLD and Ethernet module. Using a flexible programming feature of a CPLD, a UART [2] can be designed in it. If many UARTs are in it, the pc system has the capacity of communication with multiple serial ports. The Ethernet module provides Ethernet communication and is configured at the time of initialization. The function of Gateways is to achieve communication between the serial devices and Ethernet module.

When Gateway receives data from module, it will choose useful data from serial data frame follows the protocol to communicate, and send data after completion of package. After receiving the data from Ethernet, it first unpacks the frame and determines the port number to transfer data to its buffer and adds the synchronous heads.

In this project Hardwired TCP/IP Embedded Ethernet Controller chip will be interfaced to CPLD [2], [3] to provide Ethernet interface.

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The data which are collected from environment send to the CPLD. From CPLD various digital signals will be captured and will be sent on a serial line. The CPLD implements all the required logic to read the data from sensors and store the data in it.

On CPLD logic also will be implemented to read data from multiple numbers of serial ports. The Ethernet module takes data from serial port and sends to PC in Ethernet form. In PC the application will be developed to read data from Ethernet.

II. THE HARDWARE SYSTEM

A. Transmitter

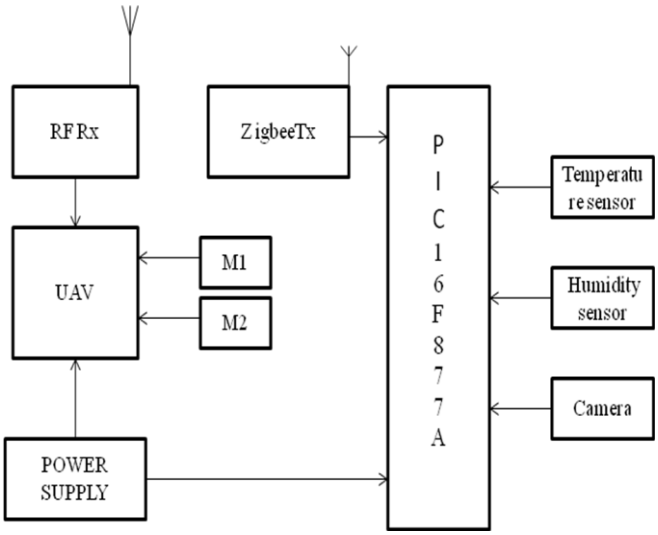

Fig. 1: Transmitter Block Diagram

Figure 1 shows the complete transmitter block diagram. Transmission operation is simpler since it is under the control of the transmitting system. It consists of mainly three sensors, zigbee transmitter module, PIC microcontroller and UAV. Sensors are temperature sensor, humidity sensor and camera. The sensors which are present in UAV are sense the data from environment and send it to the PIC microcontroller. From microcontroller with the help of zigbee transmitter the data will send to receiver side. As soon as data is accumulated in the shift register after completion of the previous character, the UART hardware creates a start bit, shifts the required number of data bits, creates and add the parity bit (if used), and the stop bits. Since transmission of a single character may take a long time, the UART will maintain a flag showing busy status so that the pc does not allow a new character for

transmission until the previous one has been completed. This work also is done with an interrupt.

B. Receiver

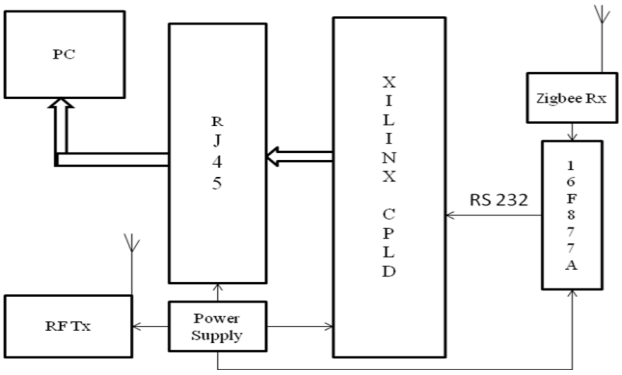

Fig. 2: Receiver Block Diagram

Figure 2 shows the complete receiver block diagram. It consists of a Xilinx CPLD development kit, zigbee receiver module, PIC microcontroller, RJ_45 Ethernet cable and pc. With the help of zigbee receiver the data is acquired from multiple serial digital modules and are transmitted to the Ethernet module through CPLD development kit, and is received by pc, by the TCP/IP protocol. The Gateway consists of CPLD and Ethernet module. Using a flexible programming feature of CPLD, a UART can be designed in it. If number of UARTs is in it, the system has the capacity of communication with multiple serial ports. The Ethernet module provides Ethernet communication and is configured at the time of initialization. The functionality of Gateways is to communicate between the serial devices and Ethernet.

III. DESIGN AND IMPLEMENTATION

A. PIC Microcontroller

PIC stands for Peripheral Interface Controller and is given by Microchip Technology to identify its single-chip microcontrollers. These devices are very successful in 8-bit microcontrollers. The reason beyond is that Microchip Technology has continuously upgraded the device architecture and added needed peripherals to the microcontroller to suit customer's requirements.

A microcontroller is a functional computer system on a chip. It consists of a processor core, programmable input/output and memory. Also Microcontrollers include an integrated CPU, memory (a small amount of RAM, programmable memory or both) and peripherals capable of input and output ports. By reducing the cost, size, and power consumption compared to a design using a separate memory, input/output devices and microprocessor.

B. CPLD Development Board

A Complex Programmable Logic Device (CPLD) is a programmable logic device with complexity between the PALs and FPGAs, and also architectural features of both devices. The building block of a CPLD is the macro cell, which contains logic implementation of disjunctive normal form expressions and more specialized logic operations. The major difference between a large CPLD and a small FPGA is that the on chip non-volatile memory is present in the CPLD. This difference is rapidly becoming less relevant, as many of the latest FPGA products also offer models with embedded configuration memory. The CPLD Development kit based on family of Xilinx XC9572XL is a low cost evaluation platform for training, developing designs and testing based on the Xilinx 9500XL family of CPLD. The CPLD board contains the total 72 macro cells, 1600 gate, 100 Pin XC9572XL CPLD with 72 user I/O's.

C. Zigbee Module

In this project the CC2500 ZIGBEE Module is presented. The CC2500 ZIGBEE Module is a transceiver module which can be easy to use ZIGBEE communication at 2.4 GHz for both transmitting and receiving the data. It can be used to transmit and receive data at 9600 baud rates from any standard CMOS/TTL source. It covers distance up to 30meters. This module is a direct line in replacement for your serial communication it does not requires any extra hardware and extra coding works in Half Duplex mode that is it provides communication in both transmitter and receiver directions, but only one direction at same time.

D. Precision Centigrade Temperature Sensors (LM35)

The LM35 series are precision integrated-circuit temperature sensors, whose output is in voltage form is linearly proportional to the Celsius (Centigrade) temperature and the unit of temperature is °C. The output voltage is measured as 10mv per °C. The operating range of an LM35 sensor is −55 to +150°C. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. The LM35's having linear output, low output impedance and also precise inherent calibration make interfacing to readout or control circuitry especially easy. It also can be used with single power supplies or with plus and minus supplies. As it draws less than 60 μA current drains, it has very low self-heating, that is less than 0.1°C in still air.

E. Humidity Sensor (SY-HS-220)

Humidity is the amount of water vapor contain in the air. Water vapor is the gas phase of water and is invisible. Higher humidity reduces the effectiveness of sweating in cooling the body, by reducing rate of evaporation of moisture from the skin. The unit of humidity is percentage. In this project SY-HS-220 humidity sensor is used to measure the humidity from environment, the current consumption of this humidity sensor is 3mA max, the operating temperature range is 0 to 60℃ and the operating humidity range is 95%RH or less.

F. Wireless AV Camera

Presenting the AV CAM-6620G for capturing the picture and videos. With the support for both Motion JPEG and MPEG-4 recording, the AV CAM-6620G is well suited for various recordings. Motion JPEG gives greater file integrity, makes it ideal for critical monitoring situations. The video size of an MPEG-4 is smaller, for that making it more useful for extended recording periods or for use in low bandwidth networks. Extreme low light sensitivity of 0.05 Lux enables recording in near total darkness.

IV. SOFTWARE IMPLEMENTATION

A. MikroC

MikroC is a powerful, feature rich development tool for PIC microcontrollers. It is designed to provide easiest possible solution for developing applications such for embedded systems for the programmer, without compromising with performance or control. PIC controller and C fit together well, PIC is known the most popular 8-bit chip in the world, used in a variety of applications and C good for its efficiency, for developing embedded systems is the natural choice. MikroC provides a successful match feature for ANSI compliant compiler, broad set of hardware libraries, highly advanced IDE and comprehensive documentation.

B. Embedded-Coding language

This project contains temperature sensor and humidity sensor. The sensors are used for collecting the information from environment and send it to the PIC microcontroller, for that we need to write an embedded C coding language in MikroC tool.

For temperature sensor, we are assigning

```
int adc_rd
do {
   adc_rd = ADC_read (0);
   LCD_Out (2, 1," Tem: ");
   Usart_write ('T'); Usart_write (':');
}
```

After sensing the temp from environment with the help of temperature sensor, it will send to the microcontroller. The LCD is interfacing with port D of microcontroller which displays value on LCD. To display the temp value we need to write code as

```
void send()
{
usart_write ('T');
usart_write ('E');
usart_write ('M');
usart_write (':');
usart_write (adc_rd);
}
```

Similarly for humidity sensor, we are assigning

```
int adc_rd1
adc_rd1 = ADC_read (1);
 h= hm (adc_rd1);
 intostr (h, text);
 Lcd_Out (1, 1,"Hm:");
```

After sensing the humidity from environment with the help of humidity sensor, it will send to the microcontroller. The LCD is interfacing with port D of microcontroller which displays value on LCD. To display the humidity value we need to write code as

```
usart_write ('H');
usart_write ('U');
usart_write ('M');
usart_write (':');
usart_write (adc_rd1);
```

After displaying the data on LCD with the help of Zigbee transceiver the data will be sends to receiver side. At the receiver side the CPLD development kit receives the data from Zigbee receiver through RS232 cable.

C. Xilinx

Xilinx ISE (Integrated Software Environment) is a software tool introduced by Xilinx for synthesis and analysis of HDL designs, providing the user to synthesize ("compile") their designs, perform timing analysis, examine RTL diagrams, simulate a design's reaction to different value, and reach the target device with the programmer.

D. Verilo- Coding Language

Verilog HDL is one of the two most common Hardware Description Languages (HDL) used by integrated circuit (IC) designers and the other one is Very High Speed Integrated Circuit High Description Language (VHDL). HDL's allows the design to be simulated earlier in the design cycle in order to correct errors or experiment with different types of architectures. Designs which are described in HDL are technology independent, easy to design, easy to debug and are usually more readable than schematics, especially for large circuits.

To display the data on pc from the CPLD development kit with the help of Ethernet cable we need to write a verilog code for Ethernet module in Xilinx tool.

V. TESTING AND RESULTS

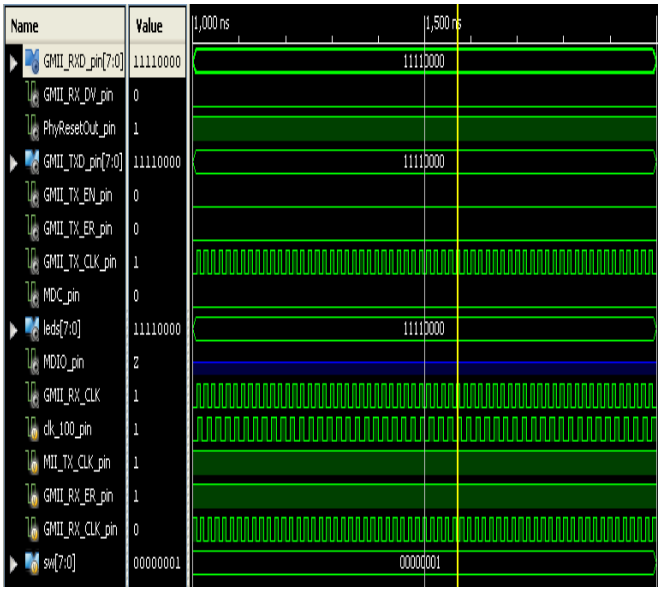

Fig. 3: simulation results

Figure 3 shows simulation result for Ethernet module. GMI_RXD_pin[7:0] and sw[7:0] are the 8bit input pin, GMI_TXD_pin[7:0] and leds[7:0] are the 8bit output pin. In this simulator we are giving input and checking for the output. What are the input we are sending from zigbee module, we required same output in the PC because the CPLD development kit here we are using as a driver to send the data in the Ethernet packet format.

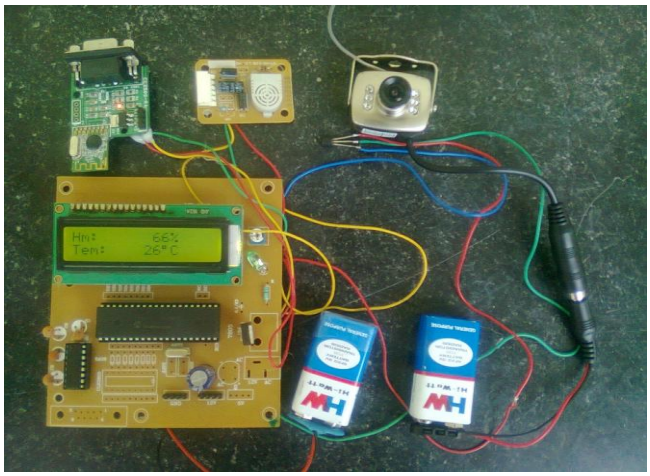

Fig. 4: Output at Normal Humidity and Temperature

Figure 4 shows the Sensors and Zigbee modules are interfacing with MCU. The sensors are Temperature sensor, Humidity sensor and Camera. Outputs for both humidity and temperature sensors are kept in normal level, camera is used for capture the photos and videos, this module will be fixed in UAV. Through the battery, power is supplying to MCU. The Green light indicating that the power is on and Red light is indicating that the Zigbee module is ready for transferring the data which are received from sensors from transmitter side.

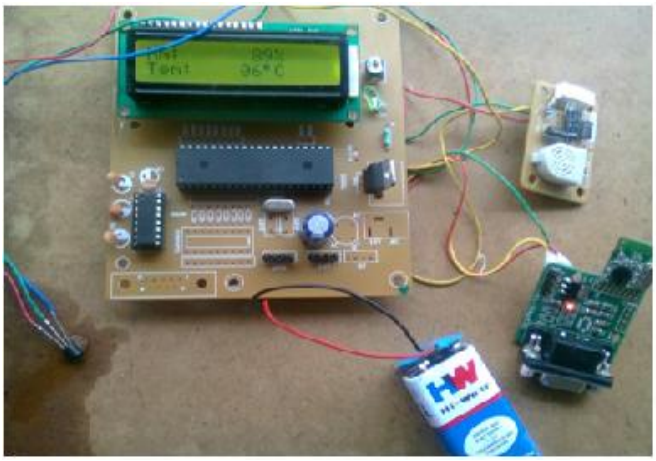

Fig. 5: Output at High Humidity and Low Temperature

Figure 5 shows the output for humidity at higher level and temperature at lower level.

Fig. 6: Output at Low Humidity and High Temperature

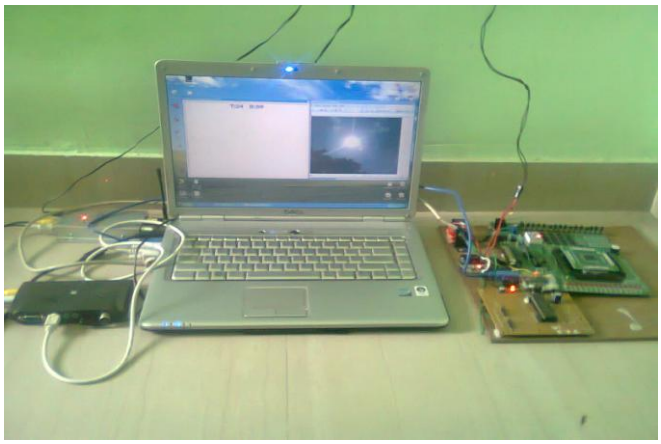

Fig. 7: Receiver Zigbee Modules is interfaced with MCU and CPLD

Figure 7 shows that Receiver Zigbee module is interfacing with MCU and CPLD development kit. The Zigbee Rceiver receives the data from Zigbee Transmitter and sends it to the CPLD development kit through RS232 cable. With the help of Ethernet reader by Microelecronica we read the data on PC. Also showing the remote to control the UAV.

Fig. 8: PC side output at Normal Humidity and Temperature

Figure 8 shows the output for temperature, humidity and camera at the pc side with the help of Ethernet reader by Microelecronica

VI. CONCLUSION

Presented a new ways for communication between pc and port device, it can simplify the communication between pc and port devices and it improves the efficiency of CPU and ensure the processing of system in real time by sensing the data from environment through temperature sensor, humidity sensor and camera, sending it to a pc with the help of zigbee transceiver and CPLD.

This design could be used in the domain of industrial automation and data acquisition systems.

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