Central Control Unit for the Outdoor Unit of IMTEL Digital Radio Relay Systems Series B

Nemanja Mitrović[1], Dragan Obradović[2] and Miroslav Perić[3]

Abstract – **Today, very complex system are not rare thing, so that fact have been made their central control units very complex itself. This paper have assign, to tell about one realization of central control unit which is a part outdoor unit of IMTEL digital radio relay systems. It's a little bit hardware, followed by complex software.**

Keywords –**Control Unit, Digital Radio Relay System.**

I. Introduction

Important assign in developing devices is to made final (release) product as much universal and easy for upgrade. The central control units that will be described in this paper have been imagined as same unit for couple similar devices.

Block diagram of Digital radio relay systems (DRRS) [1] are shown on Fig. 1. The DRRS have near and far side. Each side of the DRRS is consisting of one indoor unit (IDU) and one (1+0 version) or two (version with 1+1 protection mode) outdoor units (ODU). IDU and ODU are interconnected with single coaxial cable which transitions power supply for ODU and data signals in both ways.

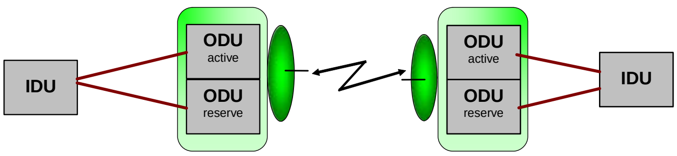

Fig. 1. Digital radio relay system block diagram

ODU block diagram is shown in Fig. 2. ODU consists of following physically modules: baseboard module, microwave module (MW transmitter with direct IQ modulator and MW receiver) microwave synthesizers and diplexer. The baseboard module is central part of ODU and it is designed to be used for more frequency bands (e.g. from 7 to 38 GHz). The baseboard module is integrated from following sub modules:

- Quad diplexer, which extracts from coaxial cable power supply and base band signal from IDU and inserts IF signal and control signals to IDU;
- DC/DC converters;
- Base band signal processing;
- Controlled IF synthesizers;
- IF automatic gain control amplifiers;
- Central control unit (CCU).

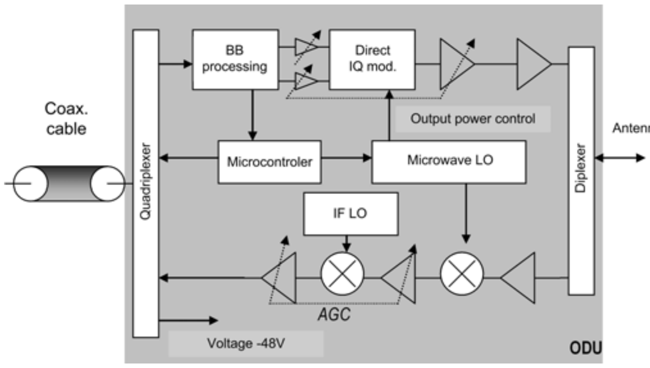

Fig. 2. Outdoor unit block diagram

The central control unit is very important for properly function of ODU and it makes possible to use same baseboard module for various frequency bands by using different configuration parameters. The central control unit has following basic functions:

- control transmitter and receiver frequency,
- control intermediate frequency,
- monitor alarms and other parameters,
- adjust transmitter power level,
- executing test modes,
- communication with IDU and other ODUs,
- maintain startup configuration parameters.

In the following sections will be described hardware and software realization of the central control unit.

II. Hardware

The complete ODU hardware was designed with attention to minimalism negative influence between modules. This is especially important for baseboard module which has many different types of components which can generate undesired signals (DC/DC converters, control unit, digital logic, etc.). Also, all components in ODU, should work in extended temperature range form -30C to +60C.

The central control unit is based on SILABS C8051F121 microcontroller [2], [3], and its realization on baseboard PCB module is shown on Fig. 3.. This microcontroller was chosen because it has integrated many peripherals like digital IOs, analog-digital and digital-analog converters, on-chip oscillator, watch-dog timer, dual UARTs, flash and RAM memory.

Since, this is DRRS that operate on very high frequencies, all controlled line are behaving as duct so there is coming to crosstalk between lines. There are couple solutions for this problem. First, filtering those lines, second make those lines

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short, third include first two and move peripheral on separate board. Most results could be reached, combining those solutions. To avoid more problems with this listen in between lines interface should have at least number of line as it possible.

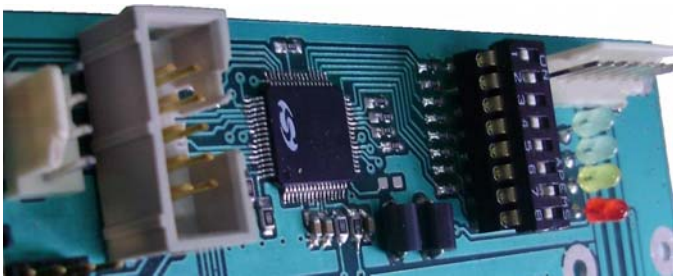


Fig. 3. Central Control Unit

In this case, for controlling main synthesizer [1], [4], [5], [6], [7], [8], which determine transmitter an receiver frequency, are used all solution. Main synthesizer is on separate board, with filtering lines on both sides. Length of lines is something that you can't reduce to zero, but you can make them smaller. Main synthesizer consists of Direct Digital Synthesis (DDS) for fine setting frequency and Phase Lock Loop (PLL) for rough setting frequency.

Both parts demand four controlling lines. As it shown on Fig. 4., those eight controlling lines, in this case are reduced to two lines. Microcontroller drives with two lines I^2C expander [10], which drives DDS and PLL with their own SPI interface [7], [8]. This is double serialization, but here, also, exists parallelization between I^2C expander [10] and I^2C EEPROM [9], which is filled with information about synthesizer. This method reduce undesired notice from digital components

Local synthesizer only consists of PLL [8], since it has only two frequencies that are depending on type DRRS. This synthesizer is on same board as CCU so its interface has short, filtered lines. Interface is SPI [8] that used three controlled lines.

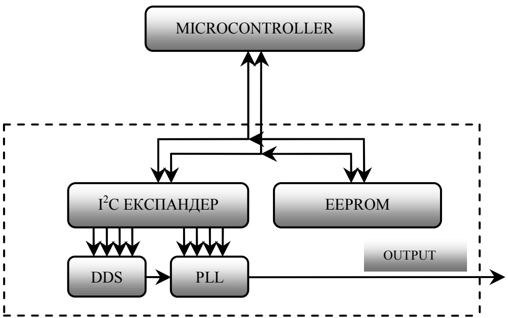


Fig. 4. Block diagram main synthesizer interface

IDU-ODU communication, on ODU side, is obtained by on UART0 port. UART1 port is used for terminal mode.

CPLD performs main task for baseband processor. Interface between CPLD and microcontroller is made with 4-bit data bus with control and address lines because distance is very short. Microcontroller can access to registers which are implemented in CPLD for settings and reading parameters.

CCU, also, work as acquisition center for information about bit rate transfer between two DRRSs. If there is some error in bit rate transfer CCU light on some diode and create alarms that can be read on IDU.

III. SOFTWARE

At the start of this paper was written that CCU hardware and software is imagined as same unit for couple similar devices. This CCU is same for DRRS that worked on 7GHz, 13GHz, 18GHz, 23GHz, 26GHz and 38GHz. At first time, developer should configure wanted device, and device will be ready for use. Next time when device is turned on it will be started as it was configured last time that it works. This is obtained by saving configuration of all devices that CCU controlling in flash memory of microcontroller SILABS C8051F121. Fig. 5. is showing CCU software block diagram.

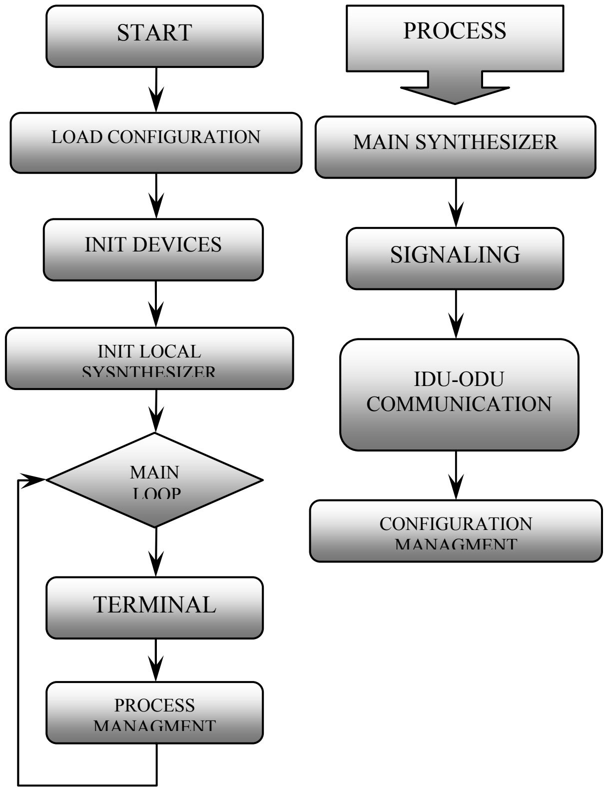


Fig. 5. CCU software block diagram

On the left side of the Fig. 5. is shown general software block diagram and on the right side of the Fig. 3. is shown main process. After loading last saved configuration, main program initialize controlled devices and set frequency of local synthesizer that depends on DRRS type. As it can be seen in main loop swaps controlled process, then save any change in configuration, and if it was demanded, writes something on the terminal.

A. *Main and local synthesizer*

Main synthesis is imagined as multi channel synthesis. Hardware setting channels is obtained by 8-bit switcher that is connected to the microcontroller, which controlled synthesis.

It is easy to see that using this kind control number of channels is limited by bits of switcher, but in here this is only secondary way setting channels. Better way setting channels is via terminal, but the bet way setting channel is via radio relay connection that is obtained by IDU-ODU communication. Only limit in number of channels is maximal and minimal frequency that microwave parts (diplexers, MW filters) of ODU can support.

CCU software has a function that calculates right frequency considering DRRS type, frequency band, sub band and desired channel. Setting channel demands order in setting DDS and PLL. Setting DDS must always go first.

Using two instead ten lines for controlling main synthesizer put us to double serialization and parallelization. From software opinion, double serialization has two levels. First level is software I^2C interface and second level is SPI that used as substructure first level - I^2C interface. Second level of software is controlling [7] and PLL [8] independent. On first level there is parallelization between I^2C expander [10] and I^2C EEPROM [9]. This is easier part, thanks to characteristic of I^2C interface. On I^2C interface can be connected several peripherals that are assign to different addresses. Double serialization and paralellization is shown on Fig. 6..

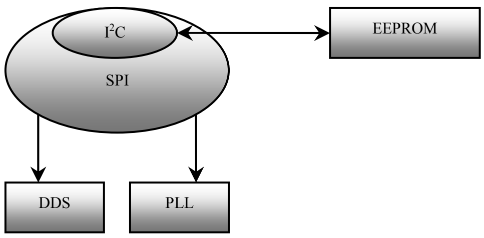


Fig. 6. Double serialization and parallelization

In the EEPROM are stored information about type, model and calibration data for synthesizer which are used from CCU software for correct calculation.

Local synthesis is setting at the startup and can be changed only via terminal mode, when DRRS type and frequency band is chosen. It has only PLL and is controlled using SPI interface.

B. Signaling

Another function of CCU is collecting information about all subsystems. Microcontroller is connected via its pins to ODU radio relay communication hardware. That way microcontroller collects errors, alarms and processes them. Processing alarms is reducing to preparing message, software filling signaling structure for IDU-ODU communication. Also, microcontroller drives led diodes that indicate some alarms. One more function of signaling module is reading temperature of microcontroller, and monitoring AGC voltages in IQ and IF section. Temperature and AGC voltages are analog signal that are converted to digital using analog to digital converters (AD converters) that are integrated in SILABS C8051F121 microcontroller.

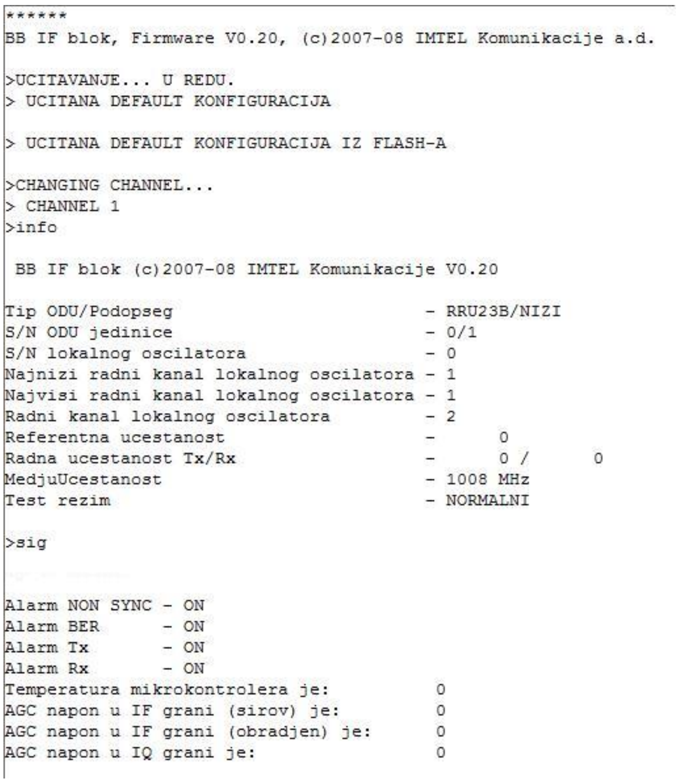
C. IDU-ODU communication

Main purpose of IDU-ODU communication is sending signaling and configuration parameters to IDU or to PC computer which are equipped with software for DRRS remote monitoring and control RRUNet [5]. From this software is also possible to setup some ODU parameters like transmitter and receiver frequency, DRRS capacity, test modes, etc.

Communications between IDU and ODU is realized with asynchrony communication with baud rate 9600 bit/s by messages with are received and transmitted form UART0 port. Each messages had destination and source addresses, type of messages and data field. With this protocol is possible to communication between PC and ODU where IDU only forward messages. Also, one ODU can communicate with other ODU on same or opposite side of DRRS. This ODU-ODU communication can be used for adaptive transmits power control (ATPC) and for realization does hot-standby protection system where only one ODU transmitter in 1+1 configuration is active in same time.

D. Terminal

Terminal mode is obtained via UART1 [7], [8] of microcontroller. UART1 routine is processing in microcontroller interrupt routine. That way processing terminal mod is lower priority and does not disturbs other more important CCU jobs.



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BB IF blok, Firmware V0.20, (c)2007-08 IMTEL Komunikacije a.d.

>UCITAVANJE... U REDU.
> UCITANA DEFAULT KONFIGURACIJA

> UCITANA DEFAULT KONFIGURACIJA IZ FLASH-A

>CHANGING CHANNEL...
> CHANNEL 1
>info

 BB IF blok (c)2007-08 IMTEL Komunikacije V0.20

Tip ODU/Podopseg                          - RRU23B/NIZI
S/N ODU jedinice                          - 0/1
S/N lokalnog oscilatora                   - 0
Najnizi radni kanal lokalnog oscilatora   - 1
Najvisi radni kanal lokalnog oscilatora   - 1
Radni kanal lokalnog oscilatora           - 2
Referentna ucestanost                     -     0
Radna ucestanost Tx/Rx                    -     0 /      0
MedjuUcestanost                           - 1008 MHz
Test rezim                                - NORMALNI

>sig

Alarm NON SYNC - ON
Alarm BER      - ON
Alarm Tx       - ON
Alarm Rx       - ON
Temperatura mikrokontrolera je:          0
AGC napon u IF grani (sirov) je:         0
AGC napon u IF grani (obradjen) je:      0
AGC napon u IQ grani je:                 0
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Fig. 7. Start terminal look with two commands

Most information about peripherals and CCU itself can be readied from terminal as witch device is configured, does it work as higher or lower half. From terminal can be readied operate channel and corresponding frequency, intermediate frequency, device serial number and is it set some test regime. Also, terminal mod can shown controller temperature, AGC voltages in both IQ and IF section and all others alarms. More, terminal can be used for setting commands to peripherals, as is changing channels. After any change to system, terminal output buffer is filling with data, so when main program come to terminal serve some warning will be shown on terminal. Start terminal look with two commands, command for viewing ODU information (INFO) and command for viewing ODU states (SIG), is shown on Fig. 7.. Primary function of terminal mode is for use in initial ODU setup and testing without using IDU.

IV. CONCLUSION

Central Control Unit is built as small complex unit. The hardware and software was designed to assign universal unit, what CCU is, since it is same for DRRS in different frequency bands.

Negative influences (noise, crosstalk, etc.) of central control unit to other ODU parts are minimized with different techniques such as relatively short control lines or inserting simple RC filter into lines.

New features like adaptive transmit power control, new test modes, can be added to ODU only with upgrade of CCU software or with minor hardware modifications.

At last, this central control unit is tested and running in many IMTEL digital radio relay systems.

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