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Radio Transmission System for Industrial Area

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ABSTRACT

The paper deals with a data transmission system operating in a large, noisy industrial area. The radio transmission system permits data and commands communication between the local units of collecting data and a central monitoring and/or command station (dispatch). The communication support are radio waves in the range 450 MHz. The transducers are of transmitter type, with 4-20 mA output signal, providing information about environmental and/or work parameters. Data are primarily acquisitioned in a data logger with microcontroller, then transmitted via a FSK radio modem and a radio station to the dispatch. Data logger can also be connected in a network. The dispatch personal computer receives and processes data and transmits commands. The system functioning is supervised by a communication software in MCS – 51 assembler and an application software in Visual C^{++}.

1 INTRODUCTION

The paper presents a radio data transmission system used in an industrial area. This system is used for gases pollutants monitoring in a chemical plant and for technological equipments remote control.

2 RADIO TRANSMISSION SYSTEM OVERVIEW

The transmission system achieves the communications between the local level, consisting of equipments and data collection units and the command and control central unit (dispatch).

The transmission equipment MDR, which accomplishes the communication on radio channel (data and commands emission/reception), is structured from: radio modem, radio transmission-reception unit, connection equipment and specific antenna.

The modern versions of radio-communication systems use temporal switching technique, which uses switches connected to the input and output lines having time multiplexed signals, making the connection between the input temporal channels and output temporal channels.

The switching network accomplishes the following tasks:

- Direct treatment of input and output multiplex;

- Establishing of the right connection ways which are continuously modifying in time, function of the required connection for each communication channel, as could be seen in Fig.1. The first connection – (1), switches a temporal channel of the input line A on a temporal channel of output line B, and the connection (2) switches a temporal channel of input line (A) on a channel of output line C.

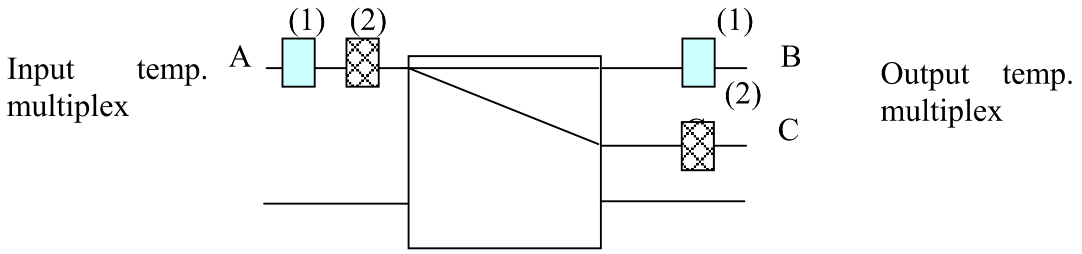

Fig. 1 Connection ways establishing

The temporal switching can be accomplished in a "synchronous" way or a "non-synchronous" way. The "non-synchronous" way, named also "package switching", is characterized by the transmission of information by data packages that are non-synchronized. These data packages could have various lengths. In order to guarantee the non-synchronous transmission, it is necessary to achieve the bit synchronization. Considering that, in absence of data packages necessary to be transmitted, synchronization words will be transmitted on the line. The checking of data packages is accomplished by the limitation signs (D), which are positioned before and after every data package. These limitation signs could be used as synchronization words. To control the traffic of these data packages, a label is associated to every package, which could allow the identifying of the right way of this package.

The structure of such a data transmission is shown schematically in Fig.2.

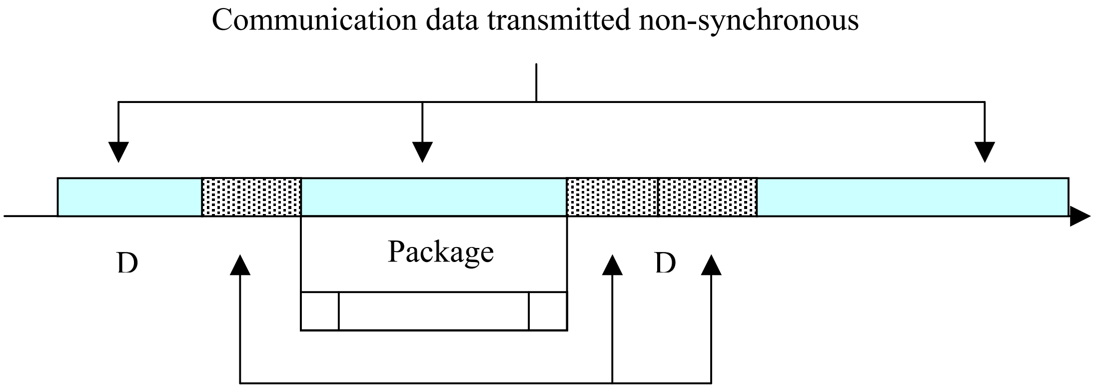

Fig.2 The structure of the "package switching" data transmission

The non-synchronous temporal switch accomplishes the following tasks:

-analyzes the received package label in order to determine the right transmission way for the package; function of the controlling mode of the way, could be considered the change of this label;

- controls the data packages way to the proper output multiplex;

- accomplishes the time multiplexing of the packages for an output multiplex.

2.1 Radio modem

The radio modem broadcasts the information by binary packages. The binary information transmission way by radio is similar to data transmission way by an usual modem. When radio data would be received by a radio modem, this modem recreates the adequate signal at the computer serial port, and therefore, the received data will be identically to the sent data.

The complete configuration must contain the modulation- demodulation unit (which is modem it-self) and the radio transmission unit (receiving-emitting station with antenna).

There are two different possible data transfer ways: synchronous and non-synchronous. Synchronous transmission by modems is usually achieved by the following procedure: the modems gather different characters groups in a memory buffer, where these characters will be prepared to be transmitted as a stream. In order to transmit this data stream, a complete synchronization between modems has to be made. This is achieved by special characters sending, the synchronizing words. When the two modems clocks will be synchronized, the data stream is transmitted.

For the non-synchronous transmission way, the data are encoded in a pulses series, including a start and an end bit. The start bit is necessary to inform receiving modem that will follow the transmission of a character. Then will be sent the character, followed by an end bit, which signifies that the transfer is ended.

The block diagram of the radio modem is shown in Fig.3.

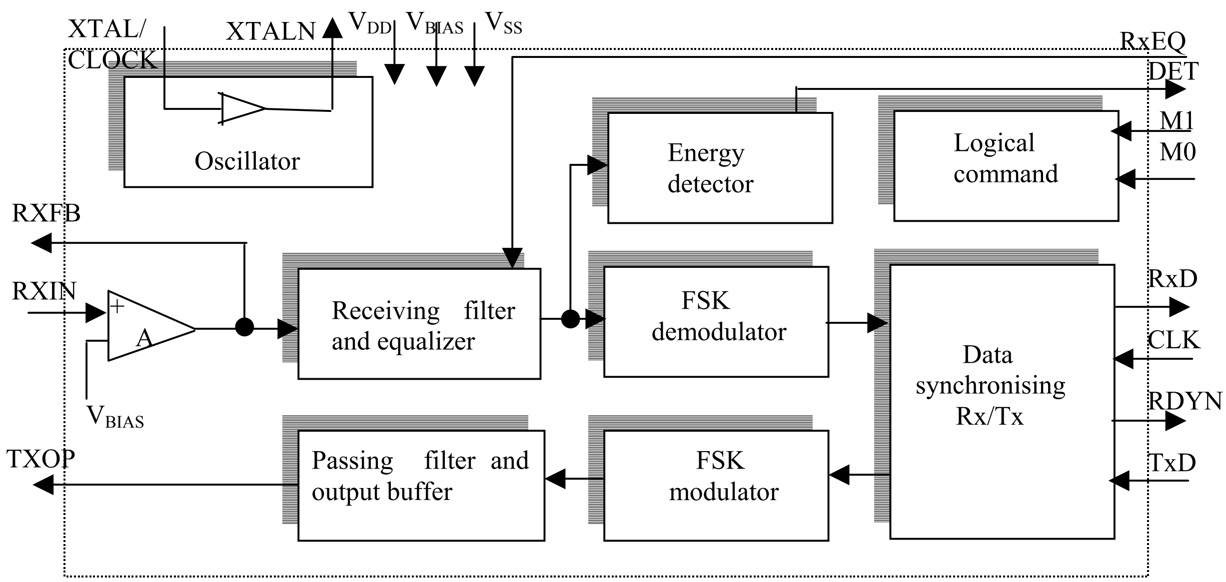

Fig.3 Block diagram of the radiomodem

Transmission is achieved by Frequency Shift Key (FSK) modulation technique, with a data transmission rate of 1200 bps. The used frequencies for transmission are 1200 Hz for “1”LOGIC and 1800 Hz for “0” LOGIC.

A typical digital data stream sequence and the adequate FSK signal is shown in Fig.4.

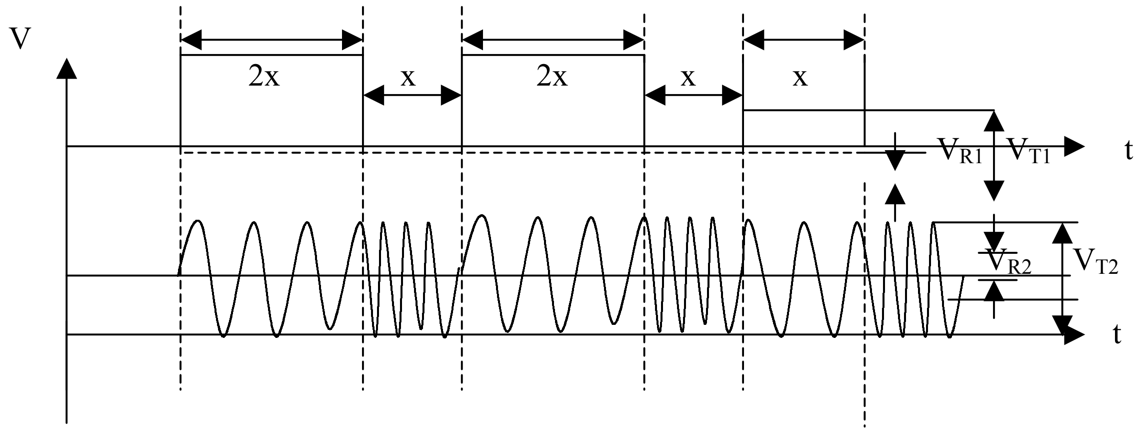

Fig 4. Digital data stream and the corresponding FSK signal

As could be seen, V_{Ti} is the transmitted voltage and V_{Ri} is the received voltage. An important advantage of the FSK modulating technique is that the signal amplitude is not affected by the distance of data transmission. The transmitted data are organized in frames containing 166 bits, structured as is presented in Fig.5. At 1200 bps, the frame period is 0.1383 s.

SB	SF	Data	Control bits

Fig.5 Transmitted data frame structure

Synchronizing bit (SB) is accomplished by a succession of “1” and “0” , on a 15 bits field , and the synchronizing frame (SC) is accomplished by a 11 bits BARKER sequence. The information itself is transmitted in the next field, having 64 bits length, by 4 bits length hexadecimal words (16 words). The last field, of 76 bits length, contains the control information.

Table 1 Radiomodem Signals

Signal		**Function**
Name	**Type**	
XTAL/CLK	I/P	oscillator input
XTALN	O/P	oscillator output
M0	I/P	logical input for function mode setting
M1	I/P	logical input for function mode setting
RXIN	I/P	Rx input amplifier
RXFB	O/P	Rx output amplifier
TXOP	O/P	FSK generator output
V_{ss}	supply	ground
V_{BIAS}	O/P	Supply voltage, internally generated
RXEQ	I/P	logical input for equalizer enable/disable
TXD	I/P	logical input for each FSK modulator input
CLK	I/P	Clock pulse

RXD	O/P	logical output for each FSK demodulator output
DET	O/P	Digit output for energy detector
RDYN	O/P	*Data Ready* output
V_{DD}	supply	Positive voltage

In Table 1 are presented the required signals for the radiomodem work; I/P are input signals and O/P are output signals.

Operating mode depends of logical levels on M0 and M1 input like in Table 2.

Table 2 Radiomodem operating mode dependence of M0 and M1 logical levels

M1	M0	Rx	Tx	Synchronous data
0	0	1200 bits/sec.	75 bits/sec	Rx
0	1	off	1200 bits/sec	Tx
1	0	1200 bits/sec	off	Rx
1	1	Zero-power		-

We choose to work with data synchronising function Tx.

Data synchronising circuit for 1200bits/sec, uses microcontroller to load one bit to each pulse on CLK input. The pulse synchronization is not critical and is made by software. The circuit has two cascaded "one bit" registers. The first register input is connected to TDX signal, and the second register output supplies the FSK modulator. The second register is sampled with a 1200Hz signal, internally generated .

In Fig. 7 is presented FSK modulator working with data synchronization function Tx.

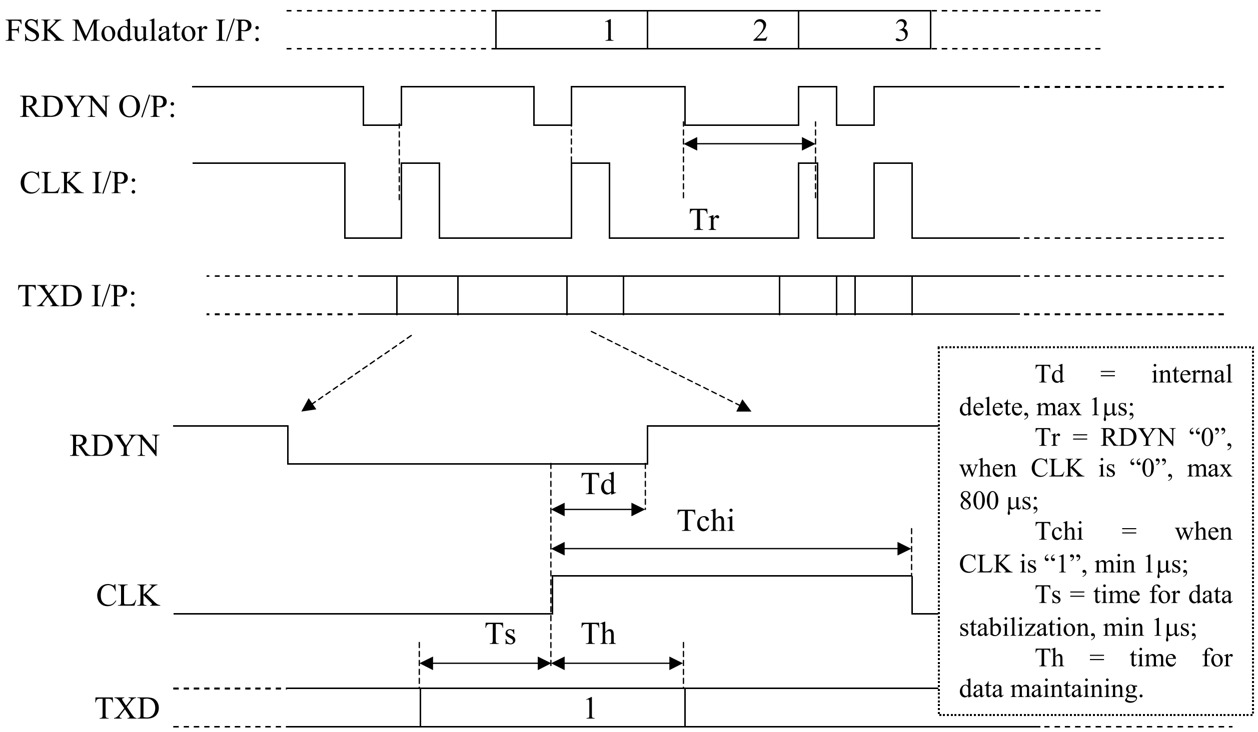

Fig. 7 Time diagram of FSK modulator working with data synchronization function Tx

2.2 Radio transmission

Data radio transmission system is designed for a radio communication in range of 450 MHz. For such systems, working in frequency range between 100MHz and 470MHz and having small output power (<50W), admitted frequency deviation is of 50×10^{-6} Hz. RF signal attenuation (in dB) depends on:

- distance between transmitter and receiver.
- open visibility between transmitter and receiver antennae.
- antenna height.

If the distance between the two antennas is D and frequency of transmission is f, relationship for RF signal attenuation, L, in free space is [1] :

$$L<dB>=32,4+20LogF<MHz> + 20LogD<km> \qquad (1)$$

For 448,525 MHz emission frequency the relationship becomes:

$$L<dB> = 85,43 + 20LogD<km> \qquad (2)$$

Effective Isotropic Radiated Power (EIRP) [2] is the power broadcasted by antenna, equal to radio station output power, minus wires attenuation and plus antenna gain:

$$EIRP = P_{out} - C_t + G_T \qquad (3)$$

Receiver input power level Si is:

$$S_i = P_{out} - C_t + G_t - P_l + G_r - C_r$$

where : P_{out}= transmitter output power <dBm>
C_t = transmission wires attenuation <dB>
G_t = transmission antenna gain <dBi>
G_r = receiver antenna gain <dBi>
P_l = route attenuation <dB>
C_r = receiver wires attenuation <dB>
P_s =receiver sensibility <dBm>
S_i = power level at receiver input <dBm>

One way to estimate the feasibility of the radio communication system is to establish the relationship between the power level at receiver input and its sensibility.

For:

- emission frequency f = 448,525MHz;
- radio station MOTOROLA GM 360 with output power P_{out} = 1W (P_{out} = 30dB);
- 10 m of wire between antennae and stations type RG214, with attenuation factor of 0,6dB/m;
-Yaggi antennae having the gain G_t = 18 dB;
-maximum distance between the local equipment and the dispatch (transmitter and receiver) of 5 km;
-receiver sensibility, P_s= -84dBm.

$$EIRP = P_{out} - C_t + G_t = 44dBm \qquad (5)$$

P_l=32,4 + 20LogF + 20LogD = 99,40dB (6)

S_i = EIRP- P_l + G_r - C_r= - 43,40dBm (7)

One can see that input receiver power is greater than its sensibility:

-43,4dBm > -84dBm

However, this power reserve does not represent a sufficient condition for a good radio communication between the local stations and the dispatch, because of the possible signal attenuation on route, which may have some causes [3], [4]:
-receiving on multiples routes;
-bad visibility between the radio antennas;
-atmosphere conditions;
-electromagnetic perturbations.
We designed the radio communication system in order to minimize all these influences and we utilize it for data acquisition and relay circuits command in a monitoring system for atmospheric pollutants.

3 CONCLUSIONS

The system is operating in a large, noisy, industrial area and has the advantage of wireless communication with minimum costs. The benefits of using this system is in decreasing human errors and improving measurement accuracy and also to supply real time data. The system permits further development by new subsystems integration.

ACKNOWLEDGMENTS

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