Atmel AVR 2004 Design Contest

Project No: A3616

Wiegand to RS232 Converter

or How to Connect to PC an Access Control Card Reader

Project Documentation

1. Introduction

Wiegand Data Interface is one of the most widespread interfaces in access control industry. Originally introduced into magnetic card readers based on Wiegand effect, nowadays it is used in virtually all kinds of access control tag readers such as proximity, magnetic stripe or bar code ones. Even biometric devices applied in access control systems are equipped with Wiegand interface. Unfortunately, this interface is completely unknown in PC world. Consequently, experimenting on access control devices or even simple checking whether data preprogrammed by vendors in access control tags suit the purchaser's order needs at least an access controller if not the whole access control system. Wiegand to RS232 converter solves the problem enabling direct connection of the access control card reader to PC and thus allowing an engineer to play with access control devices on his desk.

2. Wiegand Data Interface

Wiegand Data Interface is simplex serial interface used for transmitting data from input devices (e.g. card readers) to access controllers. It consists of two data lines called “Data 0” and “Data 1” respectively, and one “Data Return” line, which part in most cases takes ground. The reader transmits data by pulling low “Data 0” line when sending logic zero and “Data 1” line when sending logic one. The bit pulse lasts for about 50μs while interval between two bits equals approximately 2ms. Absence of pulses for about 200ms signals the new data block.

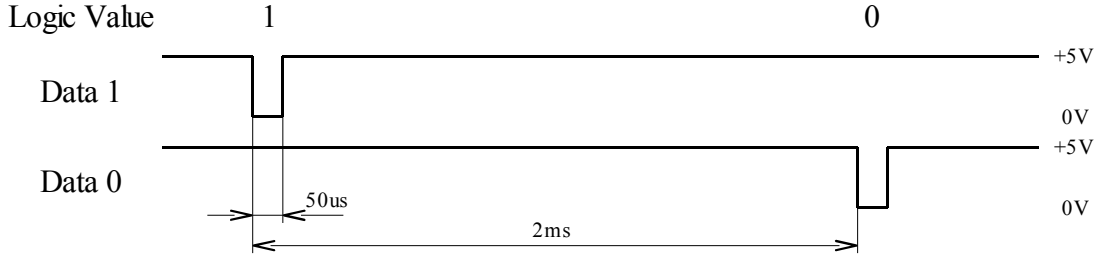

Figure 1. Wiegand interface waveforms

Depending on the data block length and structure, a few Wiegand substandards have evolved, the most widespread of which are Wiegand 26 and Wiegand 37.

Wiegand 26 data block consists of 26 bits. The first bit and the last bit are even parity bit of the first half of the data block and odd parity bit of the second half of the data block respectively, while bits b2...b9 and bits b10...b25 represent 8-bit facility code and 16-bit card number respectively. The structure of Wiegand 26 data block is shown in figure 2.

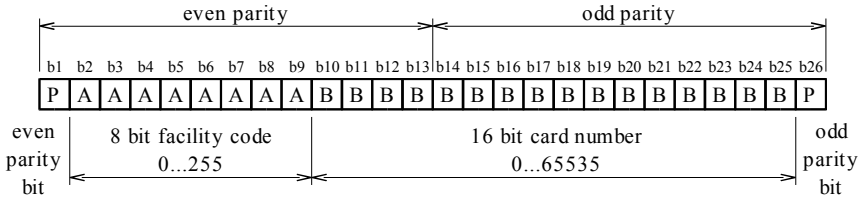

Figure 2. Structure of Wiegand 26 data block

Wiegand 37 data block consists of 37 bits. As in Wiegand 26, the first bit and the last bit are even parity bit of the first half of the data block and odd parity bit of the second half of the data block respectively. Owing to the odd number of bits in the data block, the bit b19 is counted for both even and odd parity. Bits b2...b36 represent 35-bit card number. The structure of Wiegand 37 data block is shown in figure 3.

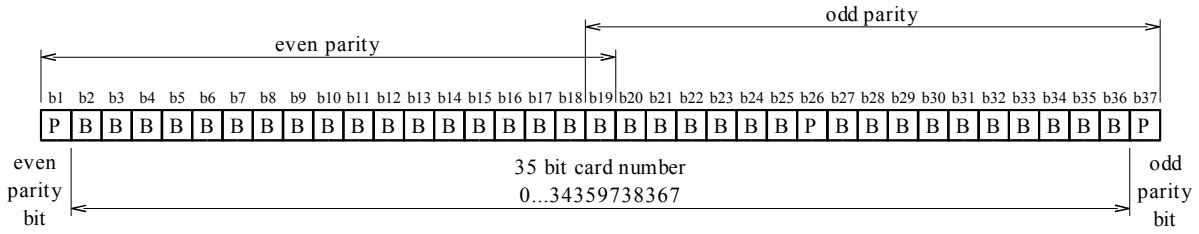

Figure 3. Structure of Wiegand 37 data block

Apart from two data output lines, the standard access control tag reader with Wiegand Data Interface is equipped with three input control lines:

- LED red
- LED green
- beeper

which are used by the access controller for signaling state of apas (e.a. point actuators and sensors). LEDs and beeper are switched on when the respective control line is pulled low.

3. Hardware

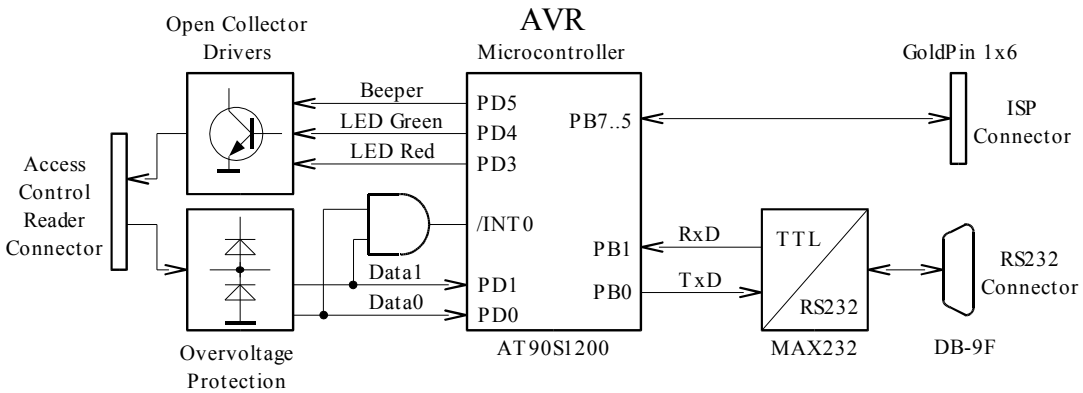

Figure 4. Block diagram of Wiegand to RS232 converter

The block diagram of Wiegand to RS232 converter is shown in figure 4. The circuit is the minimalistic one. It consists of only four parts:

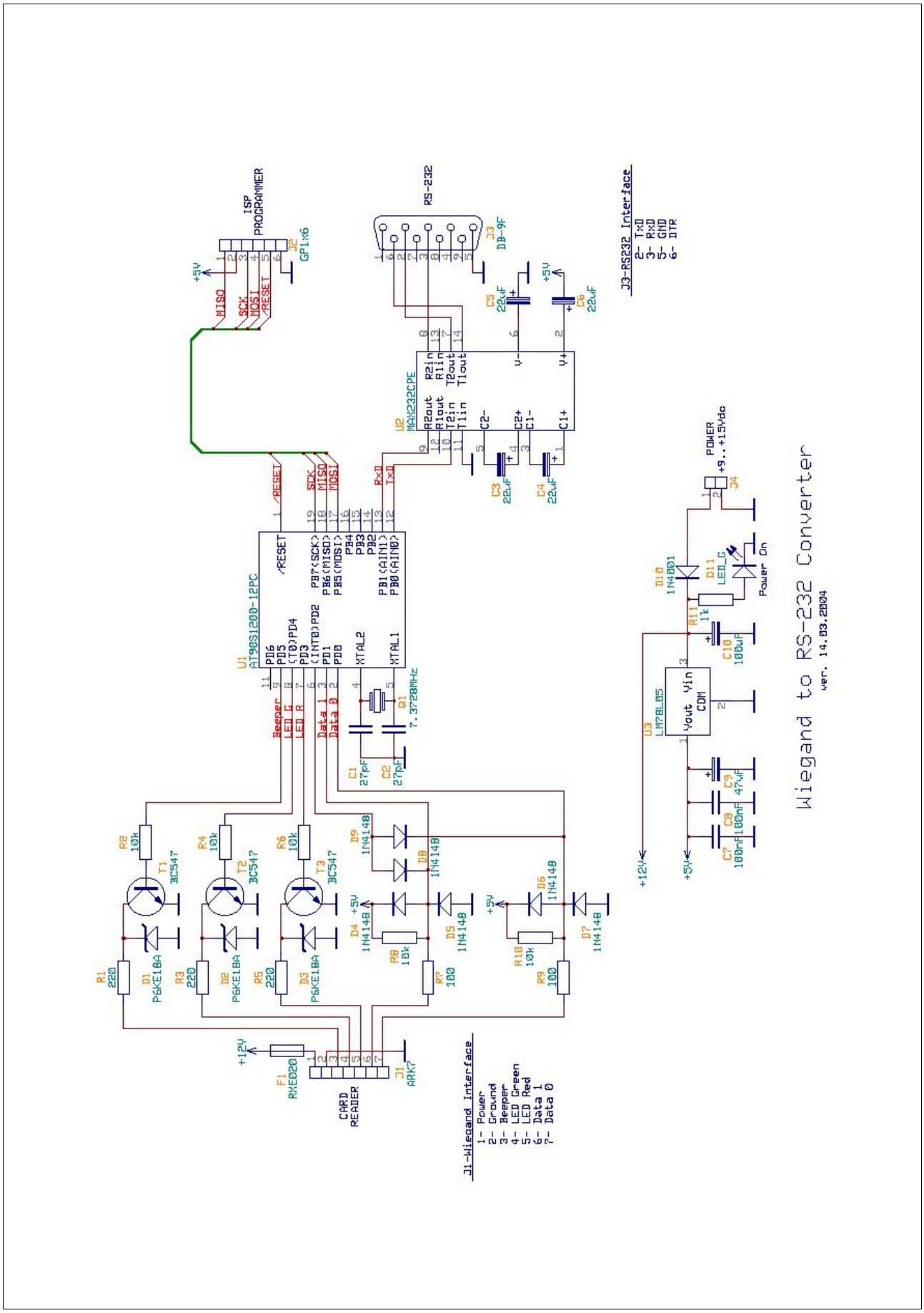

Figure 5. Schematic of Wiegand to RS232 converter

- AVR microcontroller
- AND gate
- RS232 driver / receiver
- signal conditioning and protection circuits of card reader interface.

As the microcontroller, the simplest member of Atmel AVR family (e.a. AT90S1200) has been selected. It contains very little hardware but has enough computing power to emulate needed devices in software. Additional AND gate generates interrupt whenever negative pulse on Data 0 or Data 1 line appears. The microcontroller communicates with PC via RS232 interface. The operation of the converter is straightforward. Received from the reader data are checked for errors and then retransmitted as ASCII characters via RS232 link. In opposite direction control commands are sent on receiving which the converter switches on and off the reader's LEDs and beeper.

The full schematic of Wiegand to RS232 converter is shown in figure 5. The AVR microcontroller U1 operates with 7.3728MHz crystal resonator Q1. As the RS232 voltage level converter U2, MAX232 driver/receiver in standard application circuit has been used. The AND gate is formed by diodes D8, D9 and internal pull-up circuit of pin PD2. The rest of elements protects ports of microcontroller against overvoltage (D1...D7) and overcurrent (R1...R3, T1...T3, R7 and R9), which may occur if the connected card reader uses long cable. The analog voltage regulator U3 with diode D10, which protects the circuit against wrong power supply polarity, completes the schematic.

The circuit has been assembled on two perf-boards (figure 6), one of which contains signal conditioning and protection circuits of card reader interface while the second one carries the microcontroller U1, RS232 driver U2 and voltage regulator U3. The prototype Wiegand to RS232 converter worked with access control proximity card reader made by HID Corporation (figure 7). The complete system is shown in figure 8.

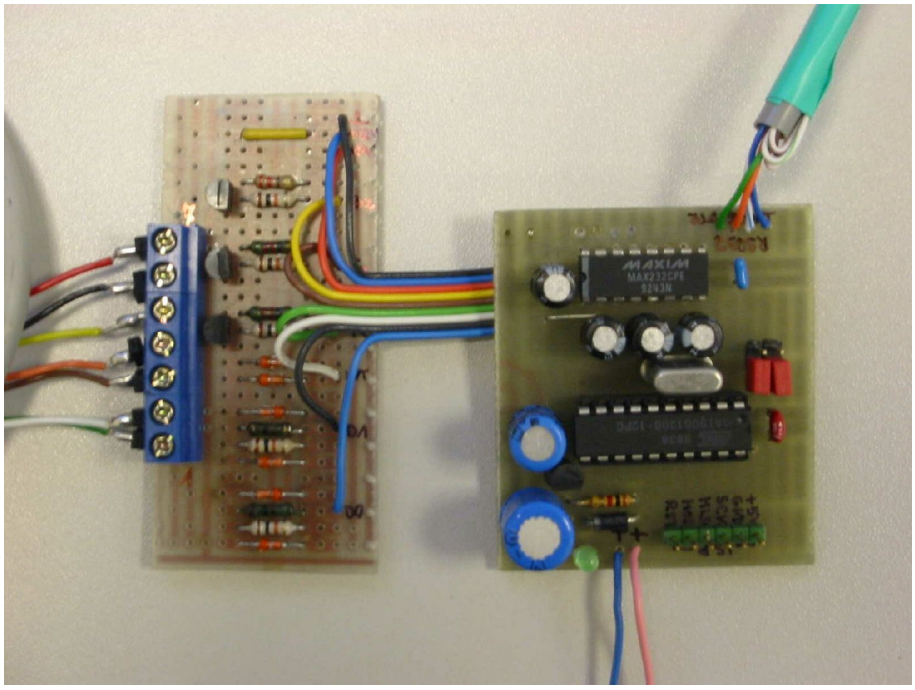

Figure 6. Wiegand to RS232 converter

Figure 7. MiniProx™ proximity card reader and two transponders: the key fob and the ISO card

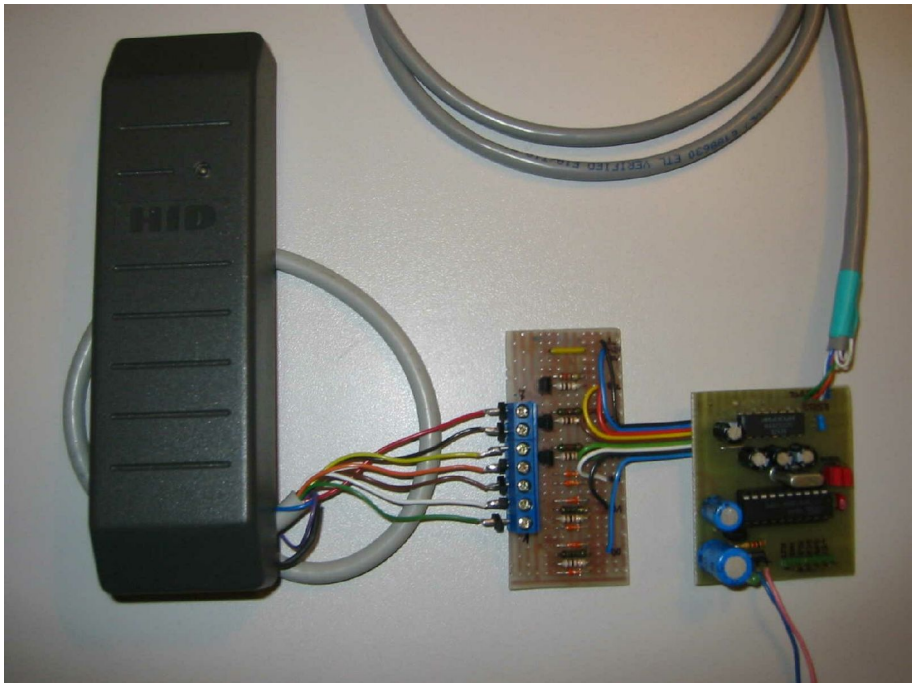

Figure 8. Complete circuit: the card reader and Wiegand to RS232 converter

4. Software

Software code of Wiegand to RS232 converter has been written in assembler in AVR Studio 3.53 environment. It consists of 3 parts:

- external interrupt 0 service subroutine
- timer T0 overflow service subroutine
- the main loop.

In external interrupt 0 service subroutine transmission from the access control reader is handled. During each interrupt one bit of the Wiagand data block is read and stored in buffer. The number of read till timeout event bits reflects Wiegand data format. The detailed flow chart of INT0 service subroutine is shown in figure 9.

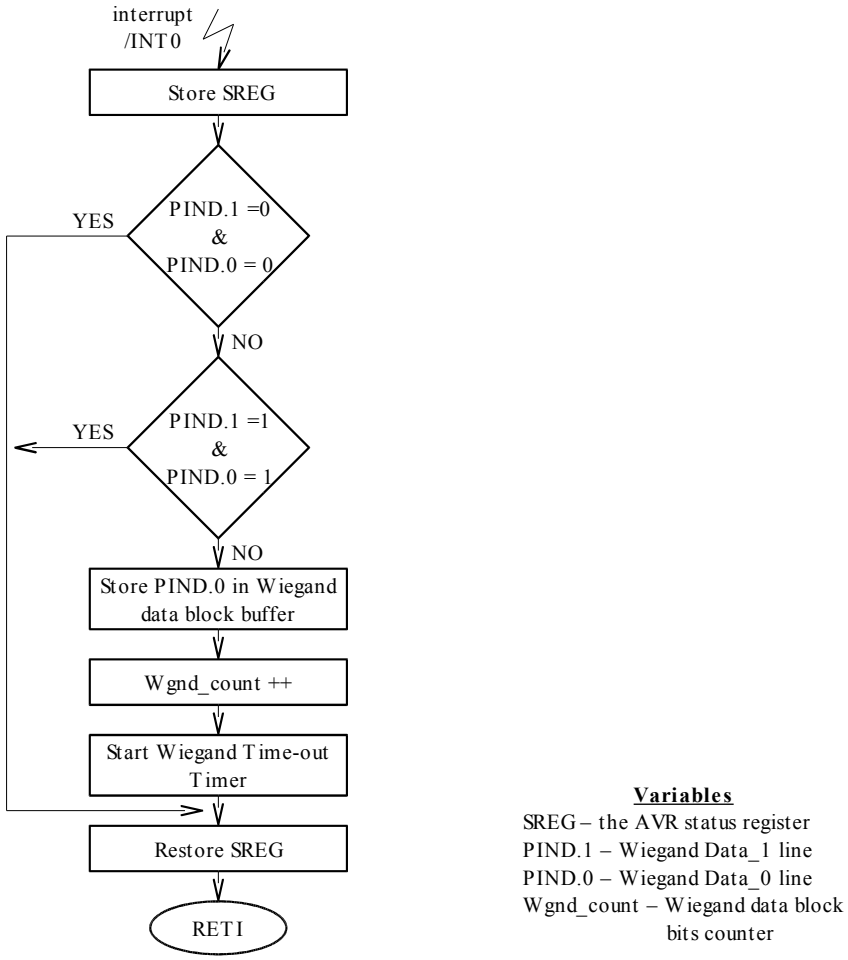

Figure 9. Flow chart of INT0 service subroutine

Timer T0 overflow interrupt is used for both: running timeout timers of access control reader and RS232 transmissions as well as for running software full-duplex UART. Due to lack of external interrupt to independently service UART receiver, reception of bits is done by polling RxD line. The line is sampled four times faster than the bit rate of RS232 link is. Consequently, during each bit there are four timer T0 overflow interrupts numbered 0, 1, 2 and 3. On detection of the falling edge of the START bit, the number of the interrupt in which the middle of the bit appears is calculated and stored. Then ten bits of the received character is read and the search of the START bit begins again. UART transmitter is organized in the same way with the exception that the

transmission of each bit starts always at interrupt number 0. Timer T0 overflow period equal to 208.33μs results in RS232 speed of 1200 bps and character format 8N1.

Operations performed in the main loop are as follows:

- checking parity of Wiegand data block
- analysis of frames incoming via RS232
- transmission via RS232 frames containing card format and card data.

Due to lack of RAM to organize UART receiver and transmitter buffers, reception of incoming frames as well as transmission is done by two state machines. Their transition charts are shown in figures 10 and 11 while the detailed list of supported by RS232 link frames is given in table 1.

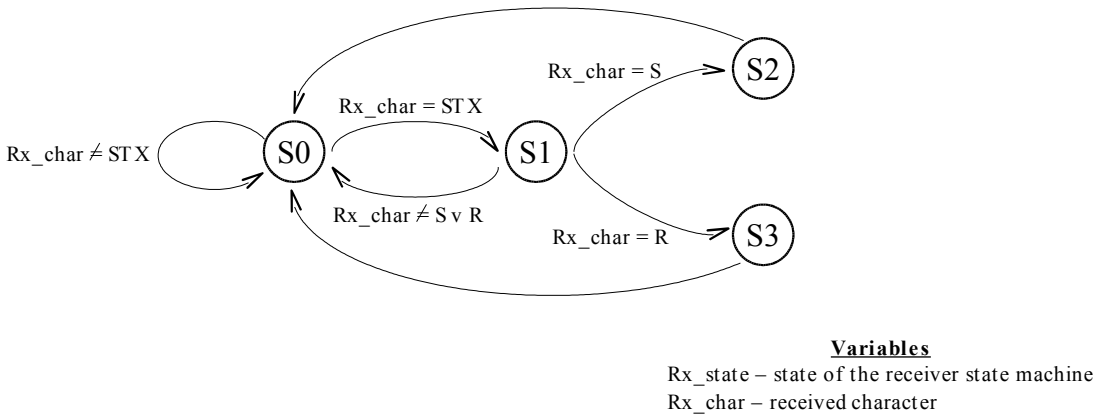

Figure 10. Transition chart of RS232 receiver state machine

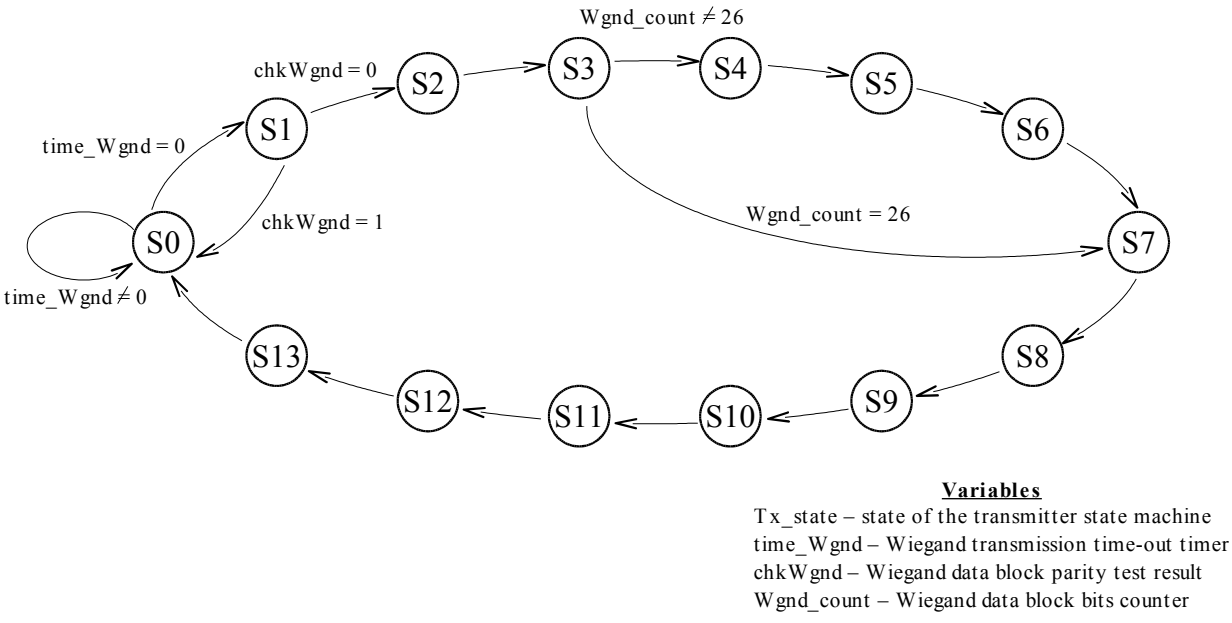

Figure 11. Transition chart of RS232 transmitter state machine

Table 1. Frames of RS232 data link

No	*Frame*	*Frame structure*
Frames transmitted by the converter		
1	Card data in Wiegand 26 format	STX S f_8 c_16 ETX
2	Card data in Wiegand 37 format	STX L c_35 ETX
Frames received by the converter		
3	Switch red LED on	STX S r ETX
4	Switch red LED off	STX R r ETX
5	Switch green LED on	STX S g ETX
6	Switch green LED off	STX R g ETX
7	Switch beeper on	STX S b ETX
8	Switch beeper off	STX R b EXT

where: STX = 0x02 – Start of Transmission character
ETX = 0x03 – End of Transmission character
f_8 – 8-bit facility code sent as 2 ASCII characters (0..9, A..F)
c_16 – 16-bit card number sent as 4 ASCII characters (0..9, A..F)
c_35 – 35-bit card number sent as 9 ASCII characters (0..9, A..F)

5. PC Application

Wiegand Card Reader Test program was designed mainly for checking on the engineer's desk data preprogrammed in access control cards by their vendors. Nevertheless, it can be used for testing card readers as it implements all commands supported by Wiegand to RS232 converter. The full list of the program features is shown in table 2.

Table 2. Operations performed by Wiegand Card Reader Test program

No	*Event*	*Operation*
1	Start of the program	Opening COM1 serial port
2	COM1 / COM2 serial port selection	Swapping the active serial port
3	Reception of the card data frame	Refreshing data card format, facility code and card number fields on display
4	„LED Red” key pressed down	Sending „Switch red LED on” command
5	„LED Red” key pressed up	Sending „Switch red LED off” command
6	„LED Green” key pressed down	Sending „Switch green LED on” command
7	„LED Green” key pressed up	Sending „Switch green LED off” command
8	„Beeper” key pressed down	Sending „Switch beeper on” command
9	„Beeper” key pressed up	Sending „Switch beeper off” command
10	End of the program	Closing active serial port

The program has been written in Borland Delphi 5. Originally it was intended for operation with Wiegand to RS232 converter connected to the universal serial ports extension card, type C104P by Moxa Technologies Co. Therefore it uses, supplied by the card manufacturer, Moxa program library Pcomm.dll. However, performed tests have shown that Wiegand Card Reader Test program works with Wiegand to RS232 converter connected to standard PC serial ports COM1 and COM2. The example screen shots are shown in figures 12 and 13.

Figure 12. Read-out of Wiegand 26 card data

Figure 13. Read-out of Wiegand 37 card data

6. Conclusion

Described in the project Wiegand to RS232 converter is fully-operational device. However, it can be enhanced by adding support of another Wiegand substandards, especially vendor-specific ones. Furthermore, presented in the project implementation of Wiegand interface (simple, cheap and consuming very little CPU resources) can be easily adapted to any AVR microcontroller as a part of bigger access control project.

7. Appendix 1 – Bill of Material

WIEGAND TO RS232 CONVERTER - BOM

Value	Package	Count	Designator					
Integrated circuits								
AT90S1200-12PC	DIP-20	1	U1					
MAX232CPE	DIP-16	1	U2					
LM78L05	TO-92	1	U3					
Transistors								
BC547	TO-92	3	T1	T2	T3			
Diodes								
1N4001	AXIAL	1	D10					
1N4148	AXIAL	6	D4	D5	D6	D7	D8	D9
P6KE18A	AXIAL	3	D1	D2	D3			
LED Green	AXIAL 3mm	1	D11					
Resistors ±5%, 0.125W								
100	AXIAL	2	R7	R9				
220	AXIAL	3	R1	R3	R5			
1k	AXIAL	1	R11					
10k	AXIAL	5	R2	R4	R6	R8	R10	
Capacitors ±10%, 63V (unless noted)								
27pF	AXIAL	2	C1	C2				
100nF	AXIAL	2	C7	C8				
22uF/16V	AXIAL	4	C3	C4	C5	C6		
47uF/6.3V	AXIAL	1	C9					
100uF/16V	AXIAL	1	C10					
Others								
Crystal 7.3728MHz	HC-49U	1	Q1					
Poly Fuse RXE020	AXIAL	1	F1					
Connector DB-9F		1	J3					
Gold Pin 1x6		1	J2					
Terminal Block ARK-7pin		1	J1					
Terminal Block ARK-2pin		1	J4					
IC Socket	DIP-20	1						

8. Appendix 2 – Project files

The complete project comprises the following directories and files:

|	
|-- AVR_Program_Full	The directory contains Wiegand to RS232 converter project files for AVR Studio 3.53 Environment
|	
|-- PC_Application_Full	The directory contains project of PC test program in Delphi 5 Environment
|	
|-- Photos	The directory contains photographs of the project
|-- Wiegand2RS.asm	Wiegand to RS232 converter source code
|-- 1200def.inc	Definitions of bit/register names for AT90S1200
|-- WiegandCardReaderTest.exe	PC test program
|-- Pcomm.dll	Serial Port Library for WiegandCardReaderTest.exe program
|	
|-- A3616_Abstract.pdf	Abstract of the project

```
|-- A3616_Project_Documentation.pdf      The full description of the project
|-- Wiegand2RS_schematic.pdf    Schematic of Wiegand to RS232 converter
|-- Readme.txt                  List of the project directories and files
```

9. Appendix 3 – Sources

AT90S1200
ATMEL Corporation
http://www.atmel.com

MAX232
Maxim Integrated Products
http://www.maxim-ic.com

Access Control Reader
HID Corporation
http://www.hidcorp.com

Universal Multiport Serial Board
Moxa Technologies Co., Ltd.
http://www.moxa.com
http://www.moxa.com.tw