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RF Reader and Tag Interrogator

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Abstract

This design project aimed to build an RFID interrogator used for detecting and identifying RF tags, can be used extensively for product identification and security purposes. The interrogator operates at 13.56 MHz and utilizes I-CODE1 protocol defined for proximity detection. Its range varies from 10 cm to 15 cm depending on the matching and tuning circuit of antenna. Reader IC, SL RC400 performs all the RF functions and provides power to the antenna. Microcontroller controls and schedules all the operations of SL RC400. The data received from tags are sent to a PC where that can be read or verified against a database and used further. This unit can be used with some modifications to meet the requirements for product identification, inventory management, library book management etc. Present RFID system has a limit on the operating distance due to direct matched antenna. Added matching and amplification circuit can increase this distance. However, longer operating range is not very well supported by SL RC400 because of its low power consumption.

CONTENTS

I. INTRODUCTION

A. Objective

RF identification systems have emerged with totally new ways to provide security and manage inventory. This project aims to establish RF communication between Reader IC(SL RC400, Philips) and I-CODE1 Labels(SL1 ICS31 from Philips) at 13.56MHz using the I-CODE1 standard. I-CODE1 standard is defined for close distances of around 10 to 15 cm. Each I-CODE1 label has a unique serial number which is transmitted to Reader IC when it comes in the proximity of later. The communication is controlled by a microcontroller(8051 architecure). This project

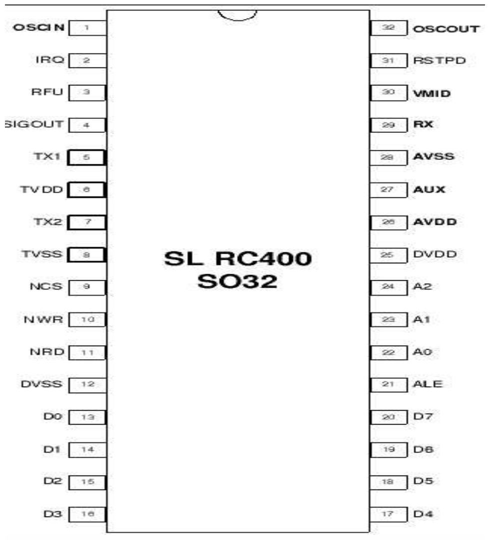


Fig. 1. Pin diagram of SL RC400

utilizes In-System-Programmable(ISP) micro-controller P89V51RD2 (Philips) since it reduces the time consumed to program the microcontroller in the developmental phase. At the front end of the system, a host computer stores all the collected information in a database, which can be used for varied applications ranging from library book management to inventory management in supermarkets.

B. Main Components Used and Block Diagram

- **Reader IC -** The Reader IC SL RC400 from Philips Semiconductors provides wireless communication at 13.56 MHz. It supports all layers of I-CODE1 and ISO 15693. The internal transmitter part of IC is able to drive an antenna designed for proximity distance (upto 100mm). The receiver part provides demodualtion and decoding circuitry for signals from I-CODE1 and ISO 15693 compatible transponders. The digital part of the IC deals in error handling. It has a 64 byte send and receive FIFO buffer, programmable timer and interrupt handling registers. There are a total of 64 registers in the IC. The IC also provides a parallel micro-controller interface with internal address latch and IRQ line.
  The IC uses either ”1 out of 256” coding, called the Standard Mode or ”RZ coding”, called the Fast Mode. This coded signal is then amplitude modulated and transmitted. This IC has an internal data buffer of 64 bytes for storing data for dynamic transaction as well as it has 256 bytes of EEPROM for storing information to be used again and again. It has three separate VDD lines namely 1) DVDD, Digital VDD; 2) AVDD, Analog VDD; 3) TVDD, Antenna VDD. All these are fed through the same power supply using filter circuits. Similarly there are three separate VSS lines namely DVSS, AVSS and TVSS.
- **Transponders/Tags/Labels -** I-CODE1 tag(SL1ICS30/31 from Philips) used in this project is a passive tag i.e. it does not require any internal power supply. Its contactless interface generates the power supply and the system clock via the resonant circuitry by inductive coupling to the reader. It also demodulates the data received from Reader and also modulates the electromagnetic field for data transmission. Data is stored in a 512 bit EEPROM which is divided into 16 blocks of 4 bytes each. The first two blocks contain the unique 64 bit serial number, which is programmed during the production process. The higher 12 blocks contain user data.
  These tags use Manchester coding to code the signal and then the signal is modulated and transmitted back. Though these tags have their own antenna, modulation and rf circuits and digital circuitry, power required to drive them is supplied by reader IC.
- **Microcontroller -** Philips P89V51RD2 is 8051 compatible (supporting four 8-bit I/O ports, three 16-bit

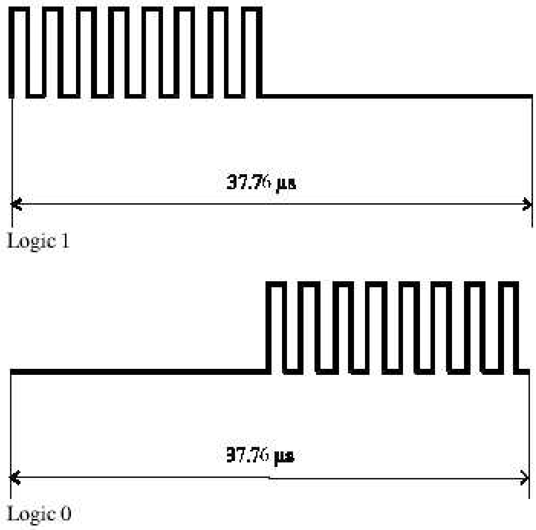


Fig. 2. Manchaster coded signal showing Logic ’1’ and Logic ’0’

timer/counters, 256 bytes RAM) in-system-programmable(ISP) micro-controller. It has 64 Kbytes on-chip flash program/data memory that can be programmed with Flash Magic software[1]. The programming voltage is internally generated from the V_{cc} pin. The main reason to choose this controller is because it can handle large memory requirements of the code and at the same time reduces the time to program without disturbing the integrity of the circuit. ISP utilizes the standard RS232 protocol and sends data using the COM port of the computer.

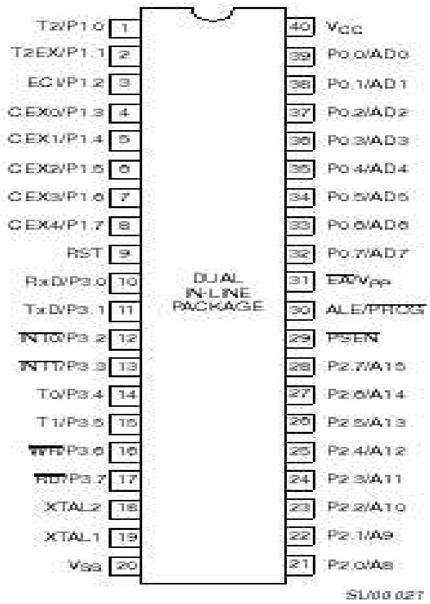


Fig. 3. Pin configuration of P89V51RD2

[1]freely available on website - http://www.esacademy.com

Block Diagram of the Whole Circuit

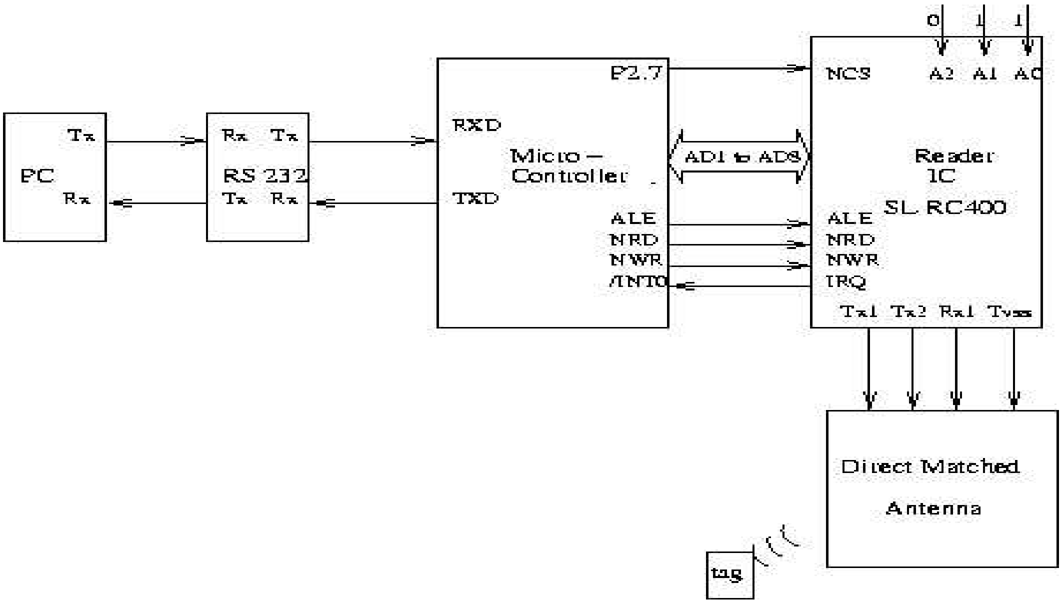


Fig. 4. Complete Circuit Block Diagram

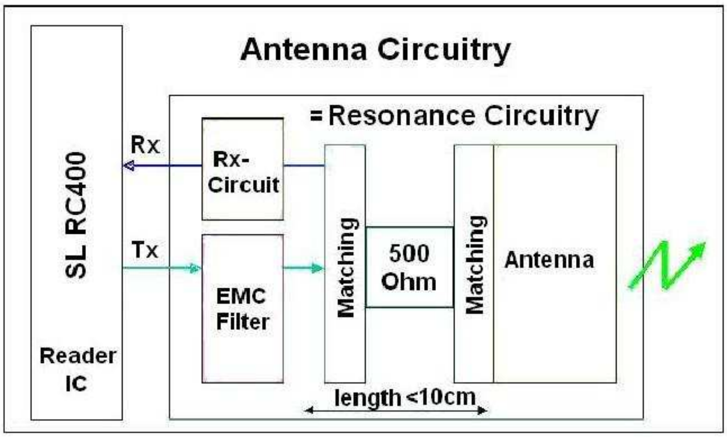


Fig. 5. Antenna Block Diagram

II. Design Options

While designing the whole circuit quite a few options were avaiable. These options are discussed below and also the reasons for choosing one of the options.

- **Antenna Design -** SL RC400 operates at a frequency of 13.56 MHz. The antenna design used are direct matched which can operate for distances upto 100 mm without any external amplification. Antenna for Reader IC can be designed in two ways namely: *1) PCB Antenna*: This kind of antenna is designed on PCB itself. Here the important considerations are the track width of antenna coil, the PCB thickness and the dielectric constant of PCB material. This kind of antenna is quite compact and robust. At the same time since geometry is well defined the centre point of the coil is easily determined. Also the matching and tuning components can sit directly on the same PCB itself. *2) Coil Antenna*: This kind of antenna is designed using coil of copper wire. Here the important considerations are the wire thickness, its geometry and the material on which the coil is wound. However, these kind of antenna is quite bulky and also not robust.

In our design we have chosen the PCB antenna. Here an important consideration was the price of antenna. Generally well optimized antennas use 4-layer PCB which are quite costly to fabricate. However, we were able to obtain a two layer antenna design from Philips which greatly reduced the price. However, this resulted in the reduction of range of antenna from typical values of 10 cm - 15 cm to 6 cm maximum.

- **Micro-controller and RF reader interface -** SL RC400 supports direct interfacing of various microcontroller in different modes.

Bus Control Signals	Bus	Separated Address and data bus	Multiplexed address and data bus
Separated read and write strobe	control	NRD[2],NWR[3],NCS[4]	NRD, NWR,NCS,ALE
	address	A0, A1 ,A2	AD0,AD1,AD2, (AD3,AD4,AD5)
	data	D0 ...D7	AD0 .... AD7
Common Read and Write Srobe	control	R/NW, NCS, NDS	R/NW , NCS, NDS, AS
	address	A0, A1, A2	AD0, AD1, AD2, (AD3,AD4,AD5)
	data	D0 ... D7	AD0...AD7
Common Read/Write With handshake (EPP)	control		nWrite, nDstrb, NCS, nAStrb, nWait
	address		AD0, AD1, AD2, (AD3,AD4,AD5)
	data		AD0...AD7

Table 1. Different Parallel Interfacing Options

SL RC400 identifies the micro-controller interface by means of various logic levels on the control pins after the reset phase. This is done by combination of fixed pin connections as given in table 2.

SL RC400	Parallel Interface Type				
	Separated Read/Write Strobe		Common Read/Write Strobe		
	Dedicated Address Bus	Multiplexed Address Bus	Dedicated Address Bus	Multiplexed Address Bus	Multiplexed Address Bus with Handshake
ALE	HIGH	ALE	HIGH	AS	nAStrb
A2	A2	LOW	A2	LOW	HIGH
A1	A1	HIGH	A1	HIGH	HIGH
A0	A0	HIGH	A0	LOW	nWait
NRD	NRD	NRD	NDS	NDS	nDStrb
NWR	NWR	NWR	R/NW	R/NW	nWrite
NCS	NCS	NCS	NCS	NCS	LOW
D7 ... D0	D7 ... D0	AD7 ... AD0	D7 ... D0	AD7 ... AD0	AD7 ... AD0

Table 2. Connection Scheme for Detecting the Parallel Interface Type

We preferred using the parallel connection since this was easy to put in the code and implement.This inteface is detected by the reader IC by the logic valiue on its control lines. The exact status of reader IC is obtained by MUC by polling the status registers of the reader IC and accordingly initiating further communication.

- **Communication modes with I-CODE1 Labels**: Two possible modes of communication are possible. They are Fastmode and Standard mode. Brief descriptions for both is as follows: *1). Standard Mode*: This mode uses ’1 out of 256’ Pulse Position Code [Fig 6]. Each bit has a pulse duration of 18.88 μs with modulation occuring in the second half of the frame. Transmission of 1 byte takes 4.833 ms. The first byte is preceeded by a start pulse modulated by 9.44 μs. This pulse comes before every starting frame.

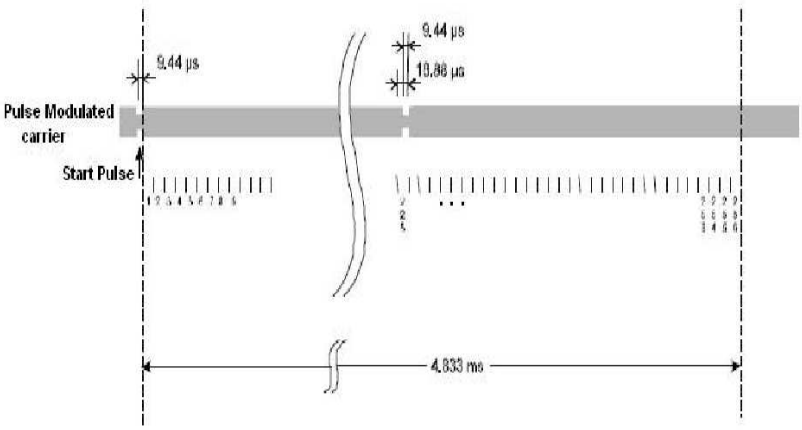


Fig. 6. Modulation Scheme in Standard Mode

2). Fast Mode: This mode is generally used for short range low power communication [Fig 7]. The modulaton technique implemented is RZ. This provides faster mode of communication. Here a starting pulse of 18.88 μs is used. 1 byte transmision takes around 302.08 μs.

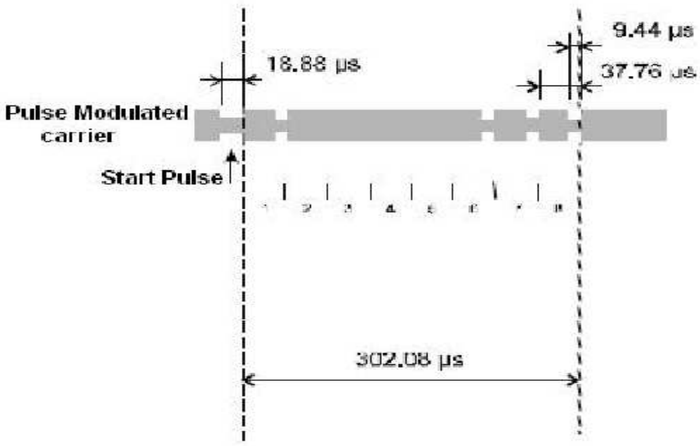


Fig. 7. Modulation Scheme in Fast Mode

In our project we have used the Fast Mode for the obvious reasons of low power consumption and fast communication.

III. Design of the Main Circuit

The whole design can be broken largely into four blocks.They are :

1) PC and Microcontroller(MUC) interface
2) MUC and Reader Chip interface
3) Reader Chip and Antenna interface
4) Antenna Matching and Tuning Circuit
5) PCB design

The communication between Reader IC SL RC400 and I-CODE1 labels is wireless. However, the interface between Reader Chip and micro-controller is a parallel interface. PC is connected to microcontroller using standard RS 232. Data received from the tags is obtained at PC via microcontroller. PC and microcontroller are interfaced using Serial Port. Following sections describe each part in detail.

A. PC and MUC interface

The 9-pin serial port of computer(COMM1/COMM2) converts the data from parallel to serial and sends it to MAX232 chip, which is essentially a voltage level converter. A standard serial interfacing for RS232 requires negative logic, i.e., logic '1' is -3V to -12V and logic '0' is +3V to +12V. This conversion of TTL level to RS232 standard is done by using a converter chip. The chip used here is the MAXIM 232 which operates at 5 volts DC. Since the interfacing doesn't use any handshake mechanism, pins 7 and 8 of DB9 i.e. RTS and CTS respectively are connected which implies that CTS is asserted along with RTS and similarly pins 1 and 6(i.e. DCD and DTR) are connected as well. Timer 1 of microcontroller is used in autorteload mode for generating timing signals required for serial communication. Count set in Timer 1 can be calculated using the following formula :

$$Count = 256 - \frac{CrystalFreq}{385 * Baudrate[kbps]} \tag{1}$$

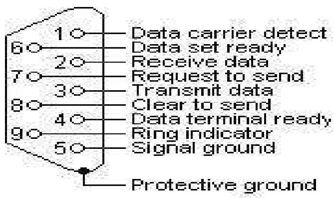


Fig. 8. DB9 pin details

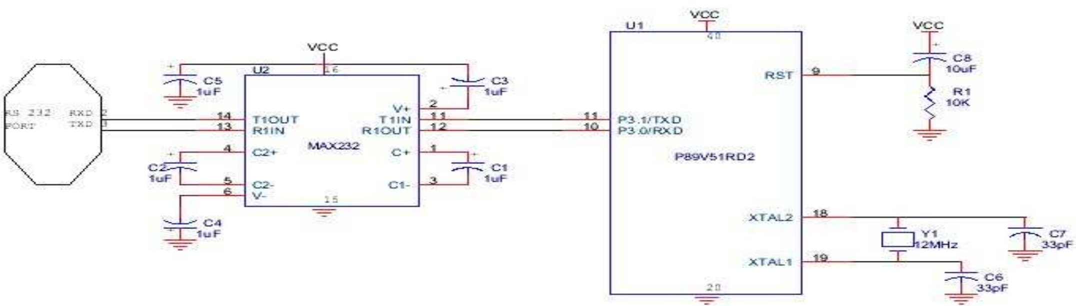


Fig. 9. DB9 connection with Max232

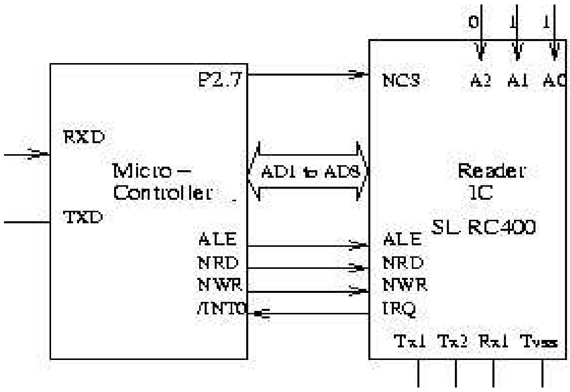


Fig. 10. Microcontroller and Reader IC interface

B. Microcontroller and Reader IC Interface

SL RC400 supports different parallel interface with microcontrollers as discussed in previous chapter. The microcontroller 89v51RD2 is interfaced parallely with Reader IC SL RC400 in Separated Read/Write Strobe mode using Multiplexed data/address bus. This is done by combination of fixed pin connections namely A0(pin 22), A1(pin 23) and A2(pin 24) of reader IC to be high, high and low respectively. The reader chip is always kept selected by making NCS low through a low output at P2.7(pin 24) of microcontroller. The read/write access to microcontroller is enabled by connecting respective pins(NRD, NWR and ALE) of microcontroller and reader [Fig. 10].

Control lines of SLRC400(pin no.)	Pins of controller connected
NRD (11)	RD (17)
NWR (10)	WR (16)
NCS (9)	P2.7 (28)
A0 (22)	VDD (logic 1)
A1 (23)	VDD (logic 1)
A2 (24)	GND (logic 0)

Table 3. Control signals(SL RC400) and MUC line connections

All Interrupts generated inside reader IC are ORed, output of which appears at pin IRQ(pin 2 of SL RC400). The signal on pin IRQ is used to interrupt microcontroller through INTO(pin 11 of 89v51RD2). For multiplexed data and address, port 0 of MUC is used.

C. Reader IC and Antenna interface

This part of the circuit is quite crucial for the working of the whole design. Lot of care must be taken while designing the EMC filter and matching circuit. Description of each individual part is given below.

- **EMC Filter**: I-CODE operates at a frequency of 13.56 MHz which is provided by a quartz crystal of the same frequency. This drives the oscillator circuit inside the reader IC and helps in transmitting carrier wave of the required frequency. However, this emitted frequency not only contains the base frequency but also the higher harmonics. To filter out these harmonics a low pass EMC[5] is implemented using capacitors and inductors. The values have been specified by Philips for 13.56 MHz and the components must be of these values with a tolerence of 1%. SMDs are prefered since they don't have wires which might also couple with the electromagnetic field and produce parasitic inductance. Table below shows the L and C values for the

[5]Electro Magnetic Coupling

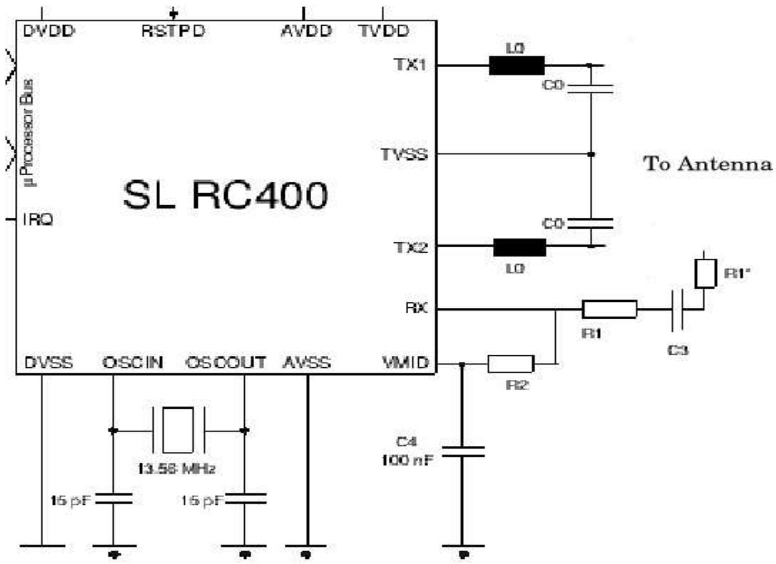


Fig. 11. EMC Filter and RX circuit

required filter.

Components	Values	Remarks
L0	1μH $\pm$ 5%	magnetic shielded,NP0 material ,SMD
C0	2* 68pF $\pm$ 2%	NP0 material , SMD

Table 4. Component values for EMC filter

- **Receiving Circuit**: This part of the circuit has been mentioned here since it also plays an important role in interfacing the reader IC with antenna. It is recommended to use the internlly generated VMID signal from the reader as the input potential for the receiver circuitry. To provide a stable ground a capacitor C is attached between VMID and Gnd. The receiving part of the RX circuit needs a voltage divider. Moreover it is also recommended to use a series capacitance(C_s) between the antenna and the voltage divider. The component values for this part is given below.

Component	Value	Remark
C4	100 nF	NP0 , SMD
C_s	1 nF $\pm$ 1%	NP0 , SMD
R1'	2.2 K ohms $\pm$ 1%	NP0, SMD
R1	560 ohms$\pm$ 1%	NP0, SMD
R2	820 ohms $\pm$ 1%	NP0, SMD

Table 5. Component List for RX circuit

D. Antenna Matching and Tuning Circuit

At the receiver/transmitter circuitry side of the RF reader, antenna is connected to SL RC400. The complete antenna design includes the antenna coil and resonance circuit design, matching of antenna circuit, the receiving circuitry and EMC low pass filtering. EMC filter and RX circuit has already been discussed in the previuos section. Antenna can be attached to Reader IC board either directly with a maximum allowable separation of 10cms with the used matching components or can have some 50 ohm cable in between IC board and Antenna board. Directly Matched Antenna is used in our design. Basic considerations in designing a PCB Antenna board are:

1) **Transmitted Power**: It should be able to transmit enough energy to power up tags/label as labels used are passive ones.
2) **Transmit data**: It should Transmit the modulated signal in such a way that, each label in its proximity (around 5 to 10 cms) should be able to receive. Signal shape and timings are important.
3) **Receive data**: Should be able to receive from labels placed in any direction in its proximity (5 to 10 cms).

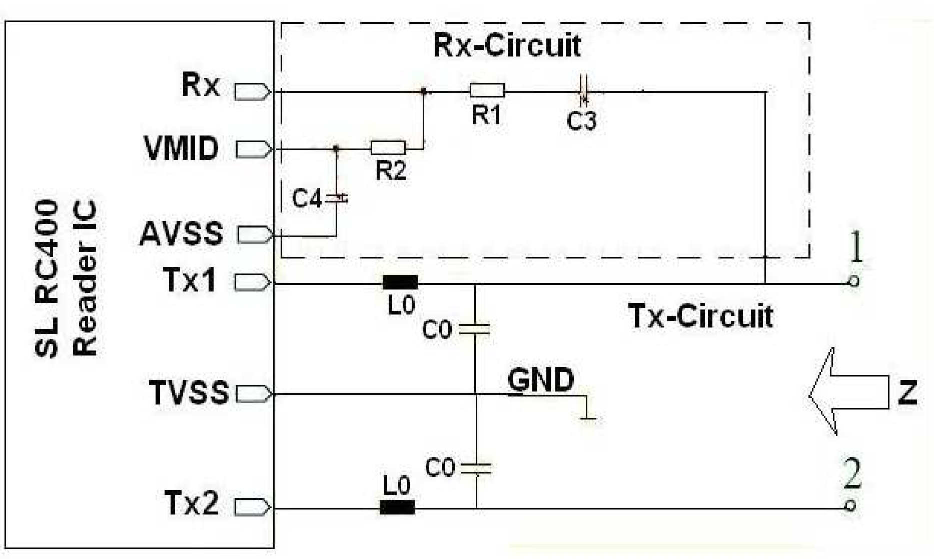


Fig. 12. Circuit on the Reader Board

Abbreviation	Explanation
L_a,L_b,R_{coil}	antenna coil components
R_{ext}	external resistor to adjust the Q. Power consumption has to be considered.
C0, C1a...C3	0603,0805,1206 SMD capacitors with tolerence of 1%
L0	Freq range and I_{max} are important considerations. Should be magnetically shielded.
C4	XR7 capacitor
R1 and R2	0603, 0805 or 1206 SMD resistors

Table 6. Abbreviations.

The antenna designed has two coils with inductances L_a and L_b, as mid point of the antenna coil is grounded. These two coils, can either simultaneously transmit or one can transmit and the other can receive. The basic point behind such a logic was to enable transceive. Also when only transmission is done then it can be done at twice the power since both the antennas can radiate. Since the antenna is direct matched, maximum separation between the Main circuit board and Antenna board should not exceed 10cms. If the antenna has to be taken to far places then it has to be connected to the main circuit using a 50 ohms cable since the Z_{ant} is adjusted to 50 ohms.

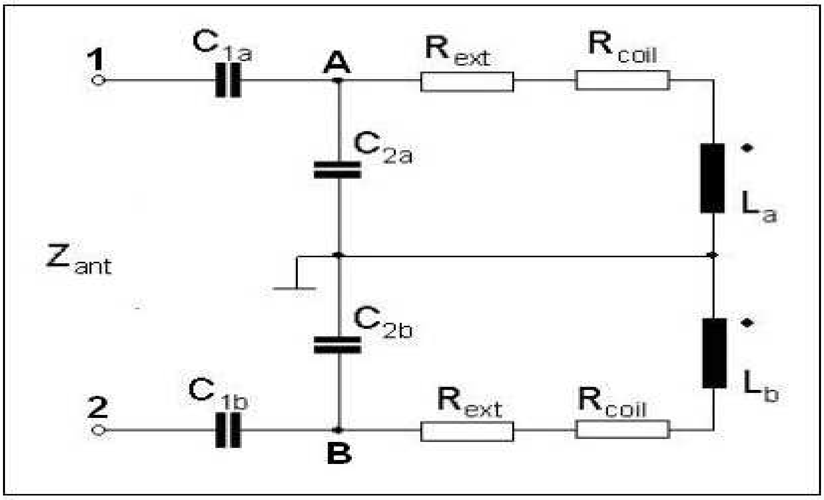


Fig. 13. Circuit on Antenna Board

1. Basic steps to design the antenna circuitry Based on certain number of given parameters a complete antenna and the required circuitry can be designed. Following steps must be performed to obtain the final circuit.

1) Design a coil and measure L and R or L and Q.
   The approximate inductance of the antenna coil can be measured using the formula:

$$L_1[nH] = 2 * l_1[cm](ln\frac{l_1}{D_1} - K)N_1^{1.8} \tag{2}$$

   - L1 – inductance of antenna
   - l1 – length of conductor loop of one turn
   - D1 – width of PCB conductor
   - K – Antenna shape factor(1.07 for circular and 1.47 for square)
   - N1 – number of turns

   The designed antenna's L and R can be measured using spectrum analyzer. Antenna should be preferably symmetrical.
2) Calculate the resonance capacitors to design a resonance circuit together with the coil. Assuming symmetrical antenna :
   L_a=L_b
   Z_a=Z_b=Z_{ant}/2
   This assumption greatly simplifies the estimation of the resonance capacitors C_{1a} and C_{2a} theoritically. However, during actual measurements the mutual inductnce of the coils should also be taken. External resistance can be calculated using the follwoung formula:

$$R_{ext} = \frac{\omega L}{2.Q} - R_{coil} \tag{3}$$

   with ω=2π*13.56 MHz
3) Tune this resonance circuit to the required impedance. The tuning series(C_{1a} and C_{1b}) and parallel (C_{2a} and C_{2b})capacitors can be calculated using the following formulae:

$$C_{2a} = C_{2b} = \frac{1}{\omega * \sqrt{\frac{\omega L}{1 - RZ_a}^2 - \frac{R^2 + \omega^2 L^2}{1 - \frac{R}{Z_a}}} + \frac{\omega L}{1 - \frac{R}{Z_a}}} \quad (4)$$

$$C_{1a} = C_{1b} = \frac{R^2 + (\omega L - \frac{\omega}{C_2})^2}{\frac{\omega L}{C_2}(\frac{1}{\omega C_2} - \omega L) - \frac{R^2}{C_2}} \quad (5)$$

4) Connect this resonance circuit to the EMC low pass filter check and again tune the circuit.
5) Check and adjust the Q of the circuit. The Q factor has a direct influence on the edges of the modulation shape. This can be used to check the Q-factor. This requires an oscilloscope with a bandwidth of atleast 50 MHz with two o fits probe. One of the probes say CH1 has to be made into a loop and kept over the antenna. Then CH2 should be connected with SIGOUT pin of the reader IC. Then SIGOUT select register(0x26) of reader IC must be set to 2[6] and then to 3[7]. Thus measuring the 3dB frequency on both sides of the central frequency Q can be measured.
6) Check and adjust the receive circuitry. Once the TX circuitry has been designed to radiate at the maximum power the RX pin of the reader IC is at high impedance and thus a voltge couples with the RX circuit. For this part two rules must be followed, viz:
   a) DC volatge level at the RX pin must be kept at Vmid (done by R2 and C4).
   b) AV volatge level must be kept within the limit:

$$1.5V_{pp} < V_{Rx} < 3V_{pp}$$

a) : If V_{Rx} is above $3V_{pp}$ R1 has to be increased. If V_{Rx} is below $1.5V_{pp}$ then R1 has to be decreased. The Rx input voltage can be checked using a tag at minimum and maximum operating distance from the antenna.

The Antenna design flow diagram is shown below:

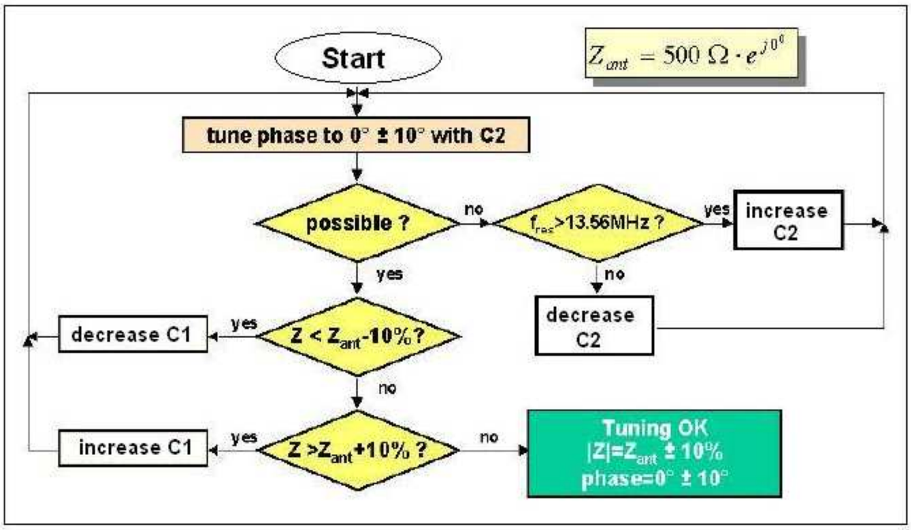


Fig. 14. Flow Diagram for Antenna Tuning & Matching

[6]Modulation Signal envelope from intrnal coder
[7]serial data stream

E. PCB Design

Since the design involves Digital, Analog and RF signals on the same board so PCB must be designed with great care. Care must be taken that minimum coupling of the devices take place. Following design considerations must be followed:

- Digital circuitry and the power supply must be kept on one part of the board and far away from the RF part. Generally digital part is associated with a lot of noise which can easily couple with the analog portion as well as RF. To minimize this effect always provide a ground plane on the board. As far as possible don't leave vacant spaces on the PCB as this may result in lot of noise coupling. Cover most part of the board with ground plane.
- Ground plane for all the three parts ie. digital, analog and RF should be made separate using decoupling capacitances. However, they should be connected together using thicker ground lines.
- As far as possible all the power lines must be made thicker than the normal lines as they are associated with maximum noise and also they carry maximum current.
- Crystal must be provided with a ground plane. It must rest on this plane tied using a bare wire connected to the ground.
- All data lines must be far away from the the RF part as the continuous data change may generate a lot of noise which can couple with the RF part.
- Use of SMDs is preferred for the RF part. Also care must be taken while soldering the wired components. Wire length must be kept minimum to minimize coupling.
- Track width of antenna PCB must be chosen carefully keeping in mind the needed inductance of the antenna. Also the matching and the tuning components should sit on the same PCB.

IV. Testing of Blocks

As discussed in the previous chapter, the whole circuit can be broken into four blocks. Testing constitutes an important part of the designing. Hence testing of individual blocks is described below.

- **PC and Micro-controller(MUC) interface-** The serial communication between PC and MUC via RS232 was tested using various softwares namely Windmill 1.2, Hyperterminal() etc.. A block of bytes was sent from PC to MUC and read back to confirm the proper communication between PC and MUC.Given below are few example assembly codes to check the communication.

```
    MOV TMOD,#20h ;timer 1 selected(in mode 2, autoreload)
    MOV TH1,#0FDh ;9600 baud rate
    MOV SCON,#50h ;enable serial reception
    setb TR1       ;start timer 1
rx: jnb RI,rx      ;receiveing data
    CLR RI
    MOV SBUF,A     ;keep receiving(data in accumulator)
    clr SBUF
    mov A,SBUF
tx: jnb TI, tx     ;transmit back the same data
    clr TI
    end
```

  This code returns the data received from PC back to PC.Also this shows the settings for serial control register and also the timet 1 settings.

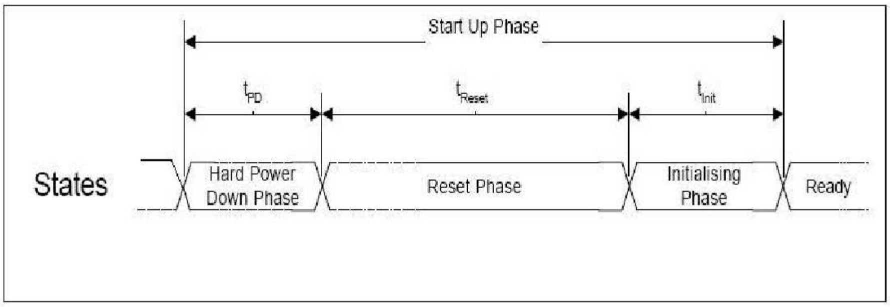


Fig. 15. Start-Up Phase

- **MUC and Reader IC interface-** On Hard Power-On or Reset, SL RC400 enters into a start-up initializing phase (Fig.4.1). During this start-up initialisation phase(Command Register of SL RC400 contains 0x3F), microcontroller cannot write anything in the reader's registers and has to come to idle state(0x00 in Command Register) for enabling the same. To ensure proper detection of microcontroller interface, the following sequence was executed:
  1) Command Register was read until the six bit register value for command is 00_{hex}.
  2) 80_{hex} was written to Page Register of SL RC400 to initialize micro-controller interface.
  3) To confirm the interface initialization, Command Register was read again to verify for presence of 00_{hex}.
- **Reader IC and Antenna Circuitry-** Since the antenna circuitry also derives its power from Reader IC, it was connected with it and a current loop was formed by shorting probes of Digital Signal Oscilloscope(DSO). So magnetic field emitted by Antenna got coupled with the loop. A carrier wave with a frequency of 13.56MHz was observed in frequency mode of DSO whose peak-peak voltage was changing by changing the position of loop. Carrier was observed up to the distance of 10-15cms.
  SIGOUT signal at pin4 of SL RC400 was taken out to check for various signals transmitted to and received from tags. For this purpose, the SIGOUTSelect register in reader IC correct settings must be done to get the desired signal at the SIGOUT pin [Fig. 16].

Bit	Symbol	Function
7-5	000	These values shall not be changed
4	TimeSlotPeriod MSB	MSB of value TimeSlotPeriod see register 0x25
3	0	These values shall not be changed
2-0	SIGOUTSelect	*SIGOUTSelect* defines which signal is routed to pin SIGOUT. 000 Constant Low 001 Constant High 010 Modulation Signal (envelope) from internal coder, actual used coded 011 Serial data stream 100 Output signal of the carrier frequency demodulator (label modulation signal) 101 Output signal of the subcarrier demodulator (Manchester coded label signal) 110 RFU 111 RFU

Table 7. Selecting Different Signals at SIGOUT Pin

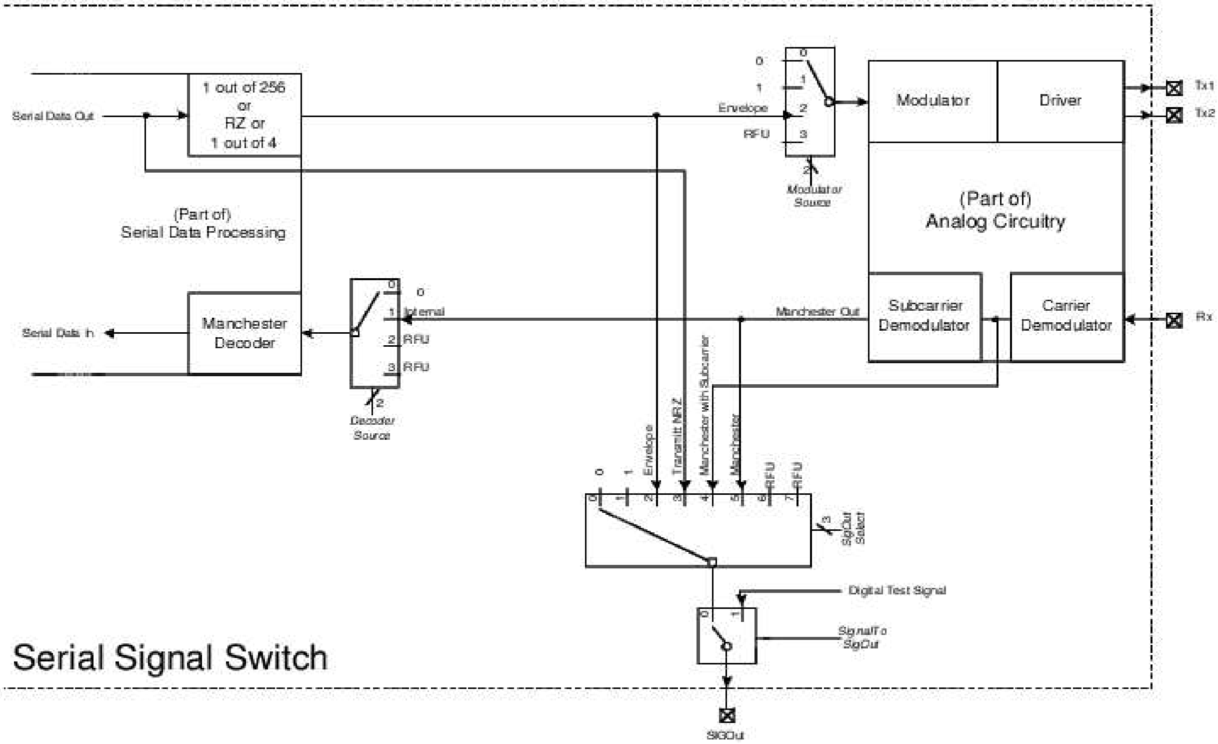


Fig. 16. Description of Signals at SIGOUT Pin

V. Experimental results and Precautions

A. Results

The antenna when tested using DSO[8] found to be radiating at a fixed frequency between 13.55 MHz to 13.7 MHz. The following graphs verify the result. Fig 5.1 shows antenna signal strength when probe is on the antenna PCB. Fig 5.2 shows antenna signal strength when probe is 6 cm away from antenna plane.

Probe Distance from antenna PCB(cm)	Signal strength(Vpp)
0	4.32
6	1.12

Table 8. Signal Strength with distance from Antenna PCB

B. Precautions while testing the circuit

Following precautions must be taken while testing the circuit.

1) Since this cicuit is RF based so its working is affected by surrounding electro-magnetic radiations. So take care that no other radiating devices for eg. power sources, antennas etc. are near the circuit.

2) To prevent interference put metallic mesh around the circuit. This will stop external EM radiations. Mesh width can be of any size smaller than the wavelength at 13.56 MHz, which is around 22 m.

3) While programming the MUC using Flash Magic never lock the security bits. This will prevent further ISP[9] on

[8]Digital Signal Oscilloscope

[9]In-System-Programming

MUC. Unlocking can be done again by parallel programming the MUC.

VI. Conclusion and Future Work

A. Conclusion

This project aimed to detect and read the I-CODE labels. This has been done sucessfully. Antenna was successfully tuned to 13.56MHz. However, presently this reader is able to detect single label only. There are also limitations on the distance from which the tag can be detected. Presently this distance is around 2 - 3 cms. This limitation is due to slight mismatch in impedance of antenna with the main board.

B. Future Work

SL RC400 supports all layers of ISO 15693 and I-CODE1. Presently, the system is configured for I-CODE1 labels and support for ISO 15693 can be developed. This will make system more versatile. Also mutiple tags detection can be implemented in future by using some complex Anti-collision algorithm. Direct matched Antenna is used in this design, this topology can be changed depending on the application by introducing a 50 ohm cable in between the Reader IC board and Antenna. This will help in introducing a Power Amplifier stage(matched with 50 ohm at both Input and Output terminal) which will increase output power of Antenna resulting into increased Antenna's sensitive distance.

VII. Appendix

A. Components

Sr.No.	Component	Type	Quantity	Remark
	CAPACITORS			
1	0.1μF	NP0, SMD	1	1% tolerance for RX circuit
2	15 pF	NP0, SMD	1	1% tolerence for RX circuit
3	68 pF	NP0, SMD	4	1% tolerence for TX circuit
4	27 pF	NP0, SMD	2	1% tolerence for matching circuit
5	100 pF	NP0, SMD	2	1% tolerence for matching circuit
6	33 pF	NP0, SMD	1	1% tol for matching circuit
7	22pF	NP0, SMD	1	1% tol for matching circuit
	INDUCTORS			
1	1 μH	NP0, SMD	2	1% tol for TX circuit
	RESISTORS			
1	820 ohms	NP0, SMD	1	1% tolerence for RX circuit
2	560 ohms	NP0, SMD	1	1% tolerence for RX circuit
3	2.2K ohms	NP0, SMD	1	1% tolerence for RX circuit

Table 9. Component list for Antenna Matching and Tuning Circuit

Sr. No.	Component	Type	Quantity	Remarks
	ICS			
1	P89V51RD2	40 pin dip	1	8051 compatible, 64K bytes Flash, 256 bytes RAM, ISP support
2	SL RC400	32pin, SO32 package	1	RF tag reader chip, ISO 15693 compatible,
3	MAXIM 232	l16 pin dip	1	RS 232 to TTL voltage level converter
4	7805	3 pin	1	5 Volts voltage regulator
	CAPACITORS			
1	1 μF	electrolytic	4	
2	100 μF	electrolytuc	1	
3	47 μF	electrolytic	2	
4	0.1 μF	mica	2	Decoupling and Power supply
5	0.1 μF	NP0, SMD[10]	1	Decoupling reader ic
6	22 pF	NP0, SMD	2	Crystal ckt of MUC
7	15 pF	NP0, SMD	2	Crystal ckt of Reader IC
8	4.7 μF	electrolytic	1	
9	1nF	mica	1	Power Supply
10	4.7 μF	NP0, SMD	2	AVSS/TVSS reader Ic
11	1nF	NP0, SMD	2	AVSS/TVSS reader ic
12	0.1μF	NP0, SMD	2	AVSS/TVSS reader ic
	RESISTORS			
1	10 K ohms		1	
	DIODES			
1	IN 4001- 4007	Rectifier diode	4	Rectifier circuit
	CONNECTORS			
1	DB9	female pin	1	for serial communication with PC
2	6 pin connector	male/female pair	2	
3	2 pin connector	male/female pair	1	
	CRYSTALS			
1	11.059 MHz	Quartz crystal	1	
2	13.56 MHz	Quartz Crystal	1	

Table 10. Component list for the circuit

B. References

Data Sheet for P89V51RD2:
Available: http://www.semiconductors.philips.com/acrobat/datasheets/P89V51RD2-02.pdf

Data Sheet for SL RC 400:
Available: http://www.semiconductors.philips.com/acrobat/others/identification/sl054331.pdf

Data Sheet for I-CODE1 Label:
Available: http://www.semiconductors.philips.com/acrobat/others/identification/sl040521.pdf

I-CODE1 protocol and Air interface:
Available: http://www.semiconductors.philips.com/acrobat/others/identification/sl040615.pdf

System Design Guide for I-CODE1 :
Available: http://www.semiconductors.philips.com/acrobat/others/identification/sl048611.pdf

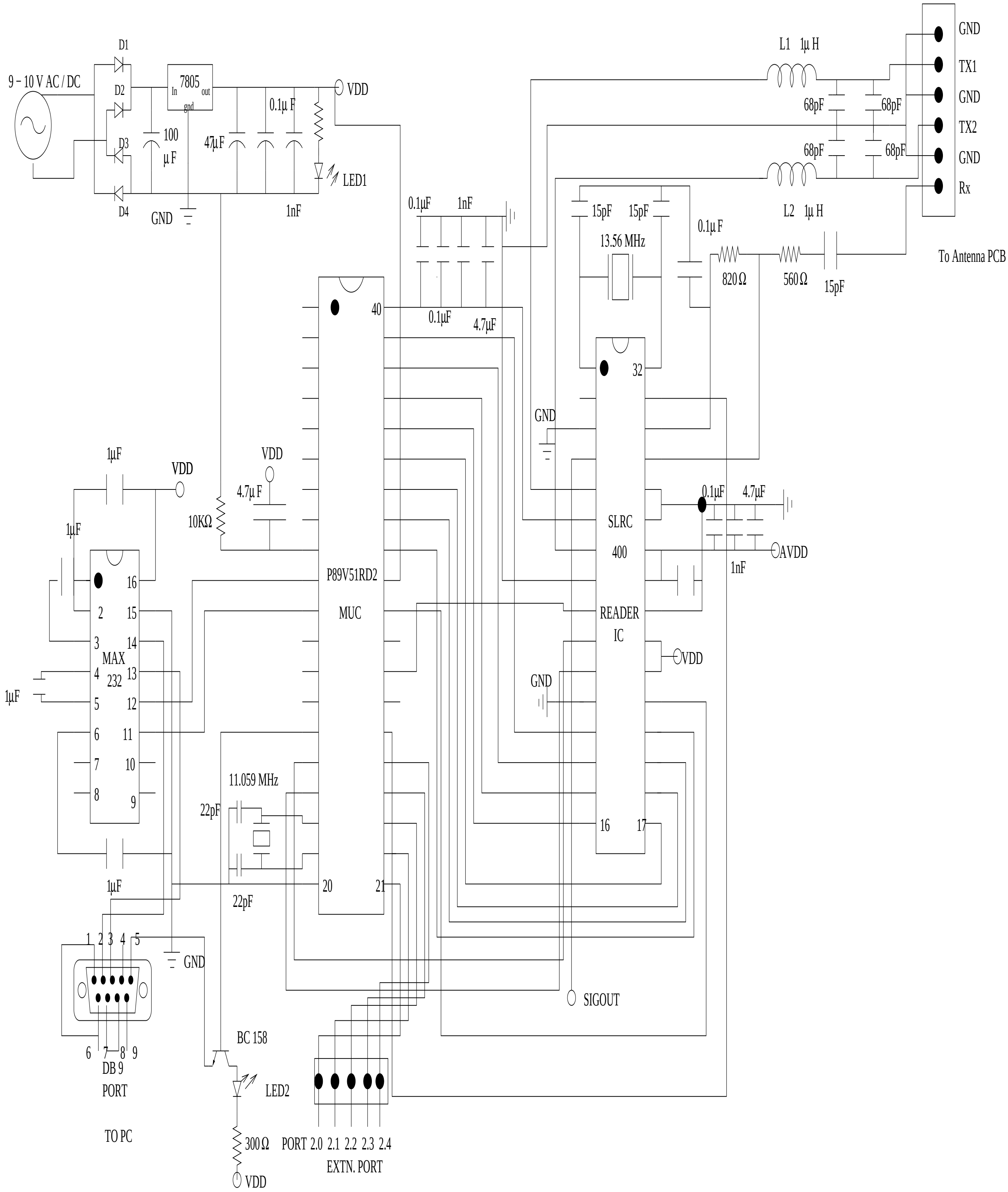
Design of Read/Write Antenna:
Available: http://www.semiconductors.philips.com/acrobat/others/identification/sl026711.pdf [11]
Available: http://www.ti.com./tiris/docs/manual/appNotes/HFAntennaDesignNotes.pdf
Available: http://www.ti.com./tiris/docs/manual/appNotes/HFAntennaCookbook.pdf

C and Assembly coding for MUC:
Available: http://www.atmel.com
Available: http://www.keil.com
The 8051 Microcontroller, Architecture, Programming and Applications. Kenneth J Ayala, Penram Publications.

RS232 Serial communication:
Interfacing the Serial RS 232 port, Craig Peacock (19th August, 2001)
Available: http://www.beyondlogic.org/serial/serial.htm

URLS fron which softwares were obtained :
Philips ISP software : Available: http://www.esacademy.com/software/flashmagic
Comm Port Debugger : Available: http://www.windmil.co.uk/serial.htm

[11]password protected



Schematic of the full circuit