

AVR® based 125kHz RFID Evaluation Kit

User Guide



Section 1

Introduction	3-1
1.1 Purpose	3-1
1.2 General Description	3-1
1.3 Evaluation Kit Features	3-1
1.4 Included in the Kit	3-2
1.5 Optional Items not included in the Kit	3-3

Section 2

Getting Started	4-1
2.1 Hardware Assembly	4-1
2.2 Navigating the Menus	4-1
2.3 Initializing a Tag	4-1
2.4 Writing a Tag	4-2
2.5 Reading a Tag	4-2

Section 3

Hardware Description	5-1
3.1 System Block Diagram	5-1
3.2 ATA2270-EK1 Main Board	5-1
3.3 ATA2270-EK1 Reader Board	5-5
3.4 125 kHz Transponders	5-8

Section 4

Software Description	6-1
4.1 Menu Hierarchy	6-1
4.1.1 RFID	6-1
4.1.2 PC	6-2
4.1.3 RTC	6-2
4.1.4 Display	6-2
4.2 Using RFID	6-2
4.2.1 Select Reader/Tag Menu	6-2
4.2.2 Reader Options Menu	6-3
4.2.3 Tag Timing Options Menu	6-3
4.3 Sample Software	6-8
4.3.1 Code Examples	6-8
4.3.2 Programming Guide	6-9
4.3.3 Fuse Settings:	6-10

Section 5

Troubleshooting	7-1
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Section 1

Introduction

Congratulations on your purchase of Atmel's AVR[®] based 125 kHz RFID Evaluation Kit. This Evaluation Kit is a complete stand-alone RFID system that demonstrates the Atmel approach to 125 kHz RFID.

This User Guide describes the setup and operation of the Evaluation Kit. Section 2, "Getting Started" describes hardware assembly and provides a demonstration of RFID. Subsequent sections discuss the variables that can be manipulated through the software.

1.1 Purpose

It is Atmel's intention to provide everything necessary for you to reach a decision on whether 125kHz RFID is the appropriate answer for your intended application. This kit includes a reader system with an LCD screen and several Atmel transponders that demonstrate communication between the Reader and Transponders. Also the hardware included provides a starting platform to develop a custom prototype. All of the software used in this evaluation kit is available on the enclosed CDROM. A PC is only required to support custom demonstrations or to load updated firmware (optional AVR Tools required to (re)flash the firmware).

As new firmware is available this user guide will change to reflect the updated features. If your evaluation kit does not appear to have the same features listed in this document, please download and install the latest firmware from the Atmel web site (www.atmel.com).

1.2 General Description

Radio Frequency Identification (RFID) has been used for more than a decade and still provides growing benefits most commonly associated with Access Control (employee badge entry), Animal ID (ear tags or pet injectables), and Auto Immobilizer (theft prevention); RFID can be used for many additional applications. The large variety of transponder features now offered allows for maximized ROE of potential systems. An RFID Reader or Interrogator functions by passing an alternating current through an air-core coil thereby generating an electromagnetic field. The magnetic field provides all of the power needed to operate the Tag, or Transponder. This source of power eliminates the need for a separate power supply on the tag and thereby reduces the size, cost, and any placement constraints. In this case the RF field operates at 125kHz. The tag responds by manipulating this RF Field.

1.3 Evaluation Kit Features

- Large 128x64 Graphic LCD with backlighting
- 4-way Joystick with center press
- 4 configurable pushbuttons
- Plug-in Connectors accept modular RFID Reader Boards

- 9-16V Power supply with reverse polarity protection
- 3V Battery backup circuit to preserve Real-Time Clock function
- Soft-power switch to shutdown system for battery operation
- Fully compatible AVR Tools Interface Connectors (JTAG/ISP)
- RS232 Interface and Serial API (Application Program Interface) support

This evaluation kit is designed for future expansion when new Reader Boards become available. Also, an interface to a PC-based development environment is made possible through the main board. These allow the basic kit to be used for a growing family of Atmel RFID products. As support for these features is added, the firmware can be downloaded from the Atmel web site and flashed into the microprocessor on the main board using very common tools such as AVR Studio, STK[®]500, JTAGICE, etc.

1.4 Included in the Kit

The kit features four basic components: the reader system, sample tags, sample ICs, and a CDROM. These basic components are comprised of the items shown below.

The reader system

- ATA2270-EK1 Main Board (1)
- ATA2270-EK1 Reader Board (1)
- 125kHz RFID Antenna Coil (1)
- Coin cell battery (CR 2032 3V Li)
- Universal Power Supply

Sample Tags

- TK5530 (3)
- TK5551 (3)
- ATA5567 ISO Card (1)
- ATA5567 Coin Cell (1)
- ATA5570 Card w/ push button
- Test Tag (1)

Sample ICs

- U2270B (3) (Extra reader chips)
- ATA5567 IC (3)
- ATA5567 mico-module (3)
- ATA5570 (3)

CDROM

- Source Code
- Data Sheets
- Application Notes
- User Guide
- Schematics and Gerber files

1.5 Optional Items not included in the Kit

The following items are useful for additional evaluation of this kit. These can be used to (re)flash the firmware provided by Atmel or customer specific application code.

- ATMEL AVR STK500 Starter Kit and Development System
- JTAGICE MKII
- AVRISP MKII
- AVR Studio 4 (downloadable from the Atmel website)



Section 2

Getting Started

The basis of this kit is the U2270B 125kHz Reader IC. The ATA2270-EK1 Reader Board (RB) demonstrates a functional reference design of this reader IC. The Reader Board and the ATA2270-EK1 Main Board (MB) constitute the Reader System. The ATA2270-EK1 Evaluation kit was designed for quick setup to speed the evaluation of a working RFID system. The following paragraphs provide guidance through hardware assembly, navigating the menus, and writing and reading a tag.

2.1 Hardware Assembly

The steps to assemble the hardware are listed below.

1. Ensure that the Reader Board is connected to the Main Board. With the Main Board oriented so that the power connector is at the lower left corner, the Reader Board should be oriented so that the antenna connector is on the lower right side.
2. Connect the supplied 125kHz Antenna. This is an air core coil that has been wound on a plastic housing.
3. Connect power using the supplied source. This is a 12V supply capable of providing 800mA. This supply comes with interchangeable universal plugs to support operation in the US, UK, Europe, and Asia.
4. The Evaluation Kit is now ready for operation. To begin, move the Power switch towards the power supply plug-in (ON position).

2.2 Navigating the Menus

The F1-F4 buttons are used to return to the previous menu. All other navigation is performed using the 4-way joystick. The “ENTER” command is accomplished by pressing the center of the joystick.

2.3 Initializing a Tag

Note: The following process contains no verification of success. It is an attempt only. Ensure that a valid tag type is present in the RF Field when performing this step.

When first beginning to work with a new tag, the tag must be placed into a fixed configuration. Choosing RFID, then the Write Configurations Menu and selecting YES will accomplish this. When ENTER is pressed the system will attempt to write the appropriate configuration block data into the selected tag type. The Configuration Block (normally Block 0) specifies the data rate, modulation type, number of blocks returned, synchronization type, and other features the tag is capable of supporting. This only needs to be done when the state of the tag is unknown.

2.4 Writing a Tag

The steps to write to a tag are listed below. If there is a problem, refer to section 5 to ensure all initial values are set in the reader system.

1. Ensure that the correct tag type is selected in the RFID>Select Reader/Tag menu.
2. Place the tag being evaluated into the RF field. Ensure proper orientation of the tag and reader antennas. The two antenna coils must be parallel to each other in order for the magnetic field to couple and provide adequate power.
3. Go to the RFID>Read/Write Menu and select One Block in the Write column.
4. Choose the desired Block. Notice moving the joystick up or down can change the Block Number.
5. Move to the thirty-two bit number shown under the Data column.
6. Use the joystick to set any hex number (edit high and low nibbles) as desired. Press ENTER to exit.
7. Press ENTER again to perform the write. Verification of the write is performed and audio feedback is provided. Also a message window will momentarily pop-up with the status of the operation.

2.5 Reading a Tag

The steps to read a tag are listed below. If there is a problem, refer to section 5 to ensure all initial values are set in the reader system.

1. Ensure that the correct tag type is selected in the RFID>Select Reader/Tag menu.
2. Place the tag being evaluated in the RF field. Ensure proper orientation of the tag and reader antennas.
3. Go to the RFID>Read/Write Menu and select Manual in the Read column.
4. Press ENTER to perform the read.
5. Observe the contents of the tag fields on the LCD. Audio feedback is used to signify the status of the read attempt. A valid read results in a beep to indicate success.

Caution

If the power supply is disconnected before the power switch is moved to off, the kit will NOT be in a low power state and the coin cell battery will drain very quickly.

6. When finished, move the Main Board Power switch away from the power supply plug-in (OFF position) to remove main power. If the unit will not be used in the near future, also disconnect the power supply.

Hardware Description

This section contains a detailed description of the hardware furnished with the Evaluation Kit.

3.1 System Block Diagram

A block diagram of the user I/O, reader, and transponder is shown in Figure 3-1.

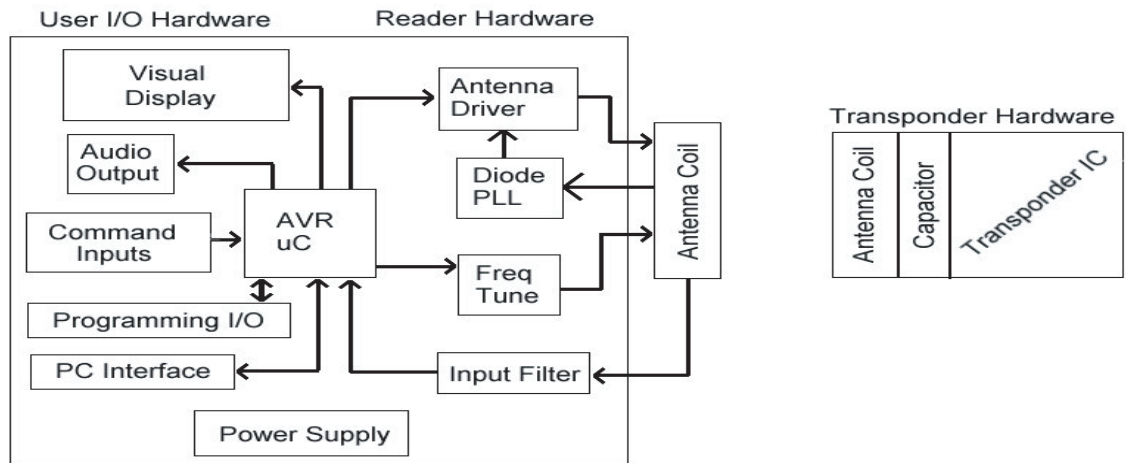


Figure 3-1. System Block Diagram

3.2 ATA2270-EK1 Main Board

Components of the ATA2270-EK1 Main Board are shown in Figure 3-2 and discussed in the following subparagraphs.

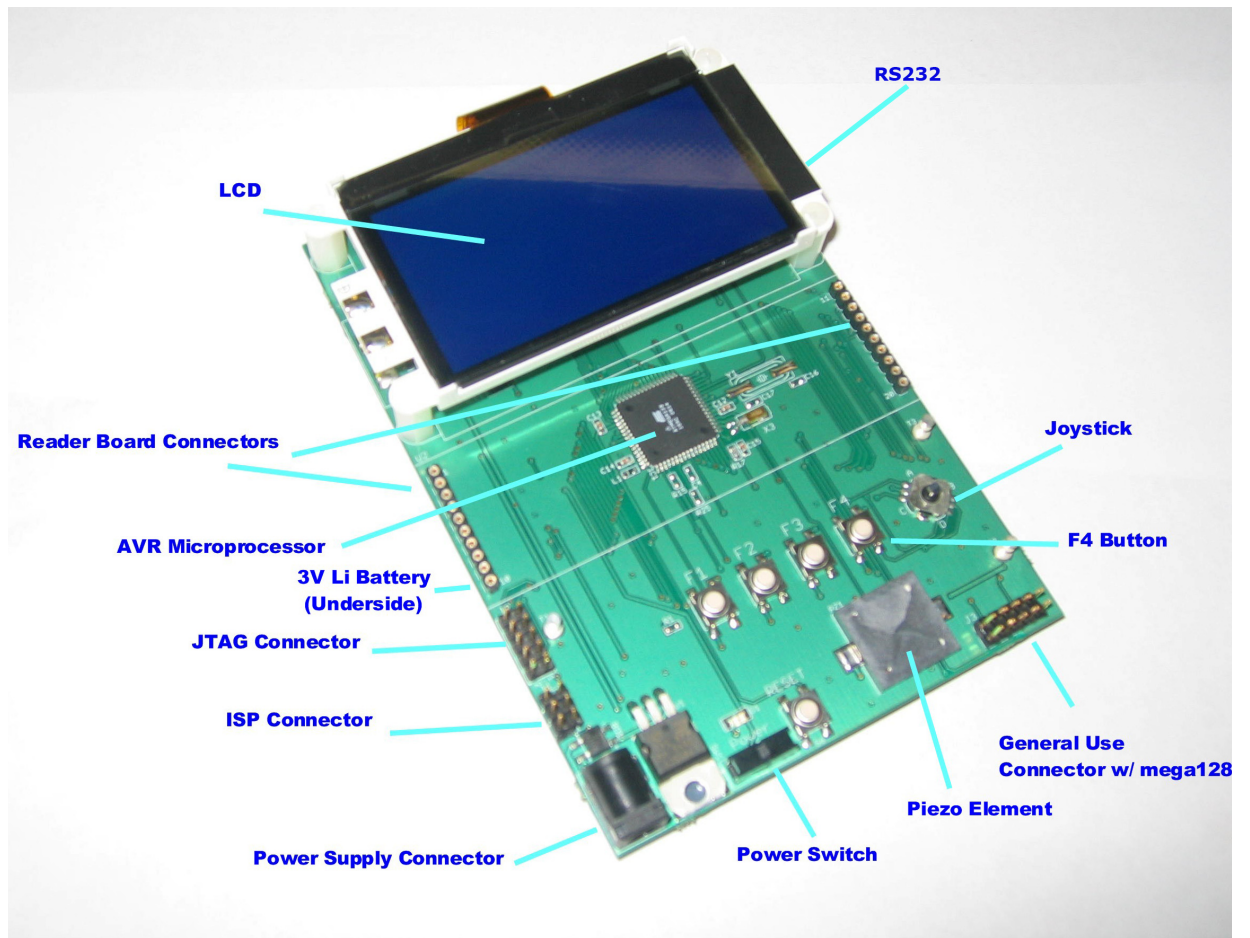


Figure 3-2. ATA2270-EK1 Main Board

- Board

The MB was designed as a generic interface platform to support Atmel's RFID reader products. This board provides a convenient way to easily work with RFID and enables the Reader Boards to be limited to the most basic RF circuits. All user interface and audio/visual feedback is contained in this board. Gerber files for this two layer board are available on request.

- LCD

The large graphic display provides an evaluation environment. Since the display supports graphics as well as text, advanced control features can be implemented. This can be used during prototype development of the end system. The size of the display (128x64) provides a large screen area to maximize visible data without having to scroll. Contrast and brightness can be adjusted through menu options to suit the environment and viewing angle.

- Reader board connections

The reader board connector's twenty pins allow the MB to interface with and control the Reader hardware. They also supply two potential power rails to the reader board. Features included are TWI, SPI, ADC (3), and Timer I/O. The pin-out is listed in Table 3-1.

Table 3-1. Reader Board Connector w/ ATmega128

Pin			Pin
1	VCC1	VCC2	11
2	PG5 (OC0B)	PD0 (SCL/INT0)	12
3	PB0 (SS/PCINT0)	PD1 (SDA/INT1)	13
4	PB1 (SCK/PCINT1)	PD4 (ICP1)	14
5	PB2 (MOSI/PCINT2)	PD6 (T1)	15
6	PB3 (MISO/PCINT3)	PD7 (T0)	16
7	PB4 (OC2A/PCINT4)	PF1 (ADC1)	17
8	PB5 (OC1A/PCINT5)	PF2 (ADC2)	18
9	PB6 (OC1B/PCINT6)	PF3 (ADC3)	19
10	GND	GND	20

■ AVR Microprocessor

The entire RFID Reader system is controlled by one AVR micro. The Atmega128 provides large flash memory for future upgrades (initial release uses 30% of the 128K flash). Additional features can be added in the future as well as providing a system to develop custom software using the kit hardware. This uC also includes 4K of EEPROM that is used to store the kit setup state. This allows returning to a previous evaluation state after a power cycle without having to reset all the variables.

■ PC Serial Connector

A Serial Port Connector is located under the LCD. This connector is enabled in a firmware upgrade is available on the Atmel Web Site (www.atmel.com). This allow the use of a complete Serial API (Application Program Interface) to control all functions of the kit from the PC. Several sample Applications have been developed and are available as well. This API allows for a top-level GUI to implement complete support for all Atmel RFID devices.

■ Power Supply and switch

The MB provides power to both the control/display portion but also to the RB through the Reader Board Connectors. The kit contains a wall power adaptor that supplies 12V and can be used around the world with interchangeable plugs. The power supply circuits on the MB protect against reverse bias and feed a 5V voltage regulator.

Caution

If the power supply is disconnected before the power switch is moved to off, the kit will NOT be in a low power state and the coin battery will drain very quickly.

The second function of the power supply circuit is to provide a battery (3V Li) backup supply for the AVR uC. This maintains the Real-Time Clock (RTC) function while the kit is not supplied with main power. The Power Switch is a "soft" switch because it does not disconnect the power supply directly. The Power Switch controls an uC I/O line that when set low, places the kit system into a low power sleep mode with the RTC still active. The main power can then be removed. In this state the battery should last for more than two years.



Note: If main power is removed before the power switch is turned off, the kit will NOT be in a low power state and the coin cell battery will drain very quickly. This will not compromise the kits RFID functionality and the system can still be used with main power applied.

■ Joystick and F4 button

The Joystick and F1-F4 button allow menu navigation and selection activation. There are provisions for additional function switches to allow future expansion of the kit. These Fn button performs the “Return to Previous Menu” function. The joystick provides navigation in four directions. The navigation of the menus should be evident as to which direction the joystick should be moved. The Joystick also acts as an “ENTER” button when it is pressed down with the Joystick centered. When pressed, the menu item currently selected is activated.

■ Interconnect to ATMEL AVR® STK500 Starter Kit and Development System and JTAGICE MKII

Programming of the flash and EEPROM memories can be accomplished using standard Atmel AVR tools. There are two interface connectors provided to accomplish this. The six-pin connector can be used with the ISP header on the STK500; the ten-pin connector is a dedicated JTAG connector and can be used with JTAGICE MKII. Both of these use AVR Studio to interface and program the evaluation kit. The pin-out of both connectors is shown in Tables 3-2 and 3-3.

Table 3-2. JTAG Connector

Pin			Pin
1	PF4 (TCK)		2
3	PF6 (TDO)		4
5	PF5 (TMS)	Reset	6
8			
9	PF7 (TDI)		10

Table 3-3. ISP Connector

Pin			Pin
1	MISO (PDO)	VCC	2
3	SCK	MOSI (PDI)	4
5	Reset	GND	6

■ General Use Interface

A ten-pin header has been included to allow a user to connect external hardware easily. This header allows access to the AVR microcontroller as well as direct access to the Reader Board. Power and Ground have also been included for ease of signal biasing. Shown in Table 3-4 are the uC pins that are

available. Compare with the pins listed on the Table 3-1 to see what connections on the reader board are applicable.

Table 3-4. General User Connector with ATmega128

Pin			Pin
1	PF1 (ADC1)	PD0 (SCL/INT0)	2
3	PF2 (ADC2)	PD1 (SDA/INT1)	4
5	PB5 (OC1A/PCINT4)	PD4 (ICP1)	6
7	PB6 (OC1B/PCINT6)	PD6 (T1)	8
9	GND	VCC	10

3.3 ATA2270-EK1 Reader Board

Components of the ATA2270-EK1 Reader Board are shown in Figure 3-3.

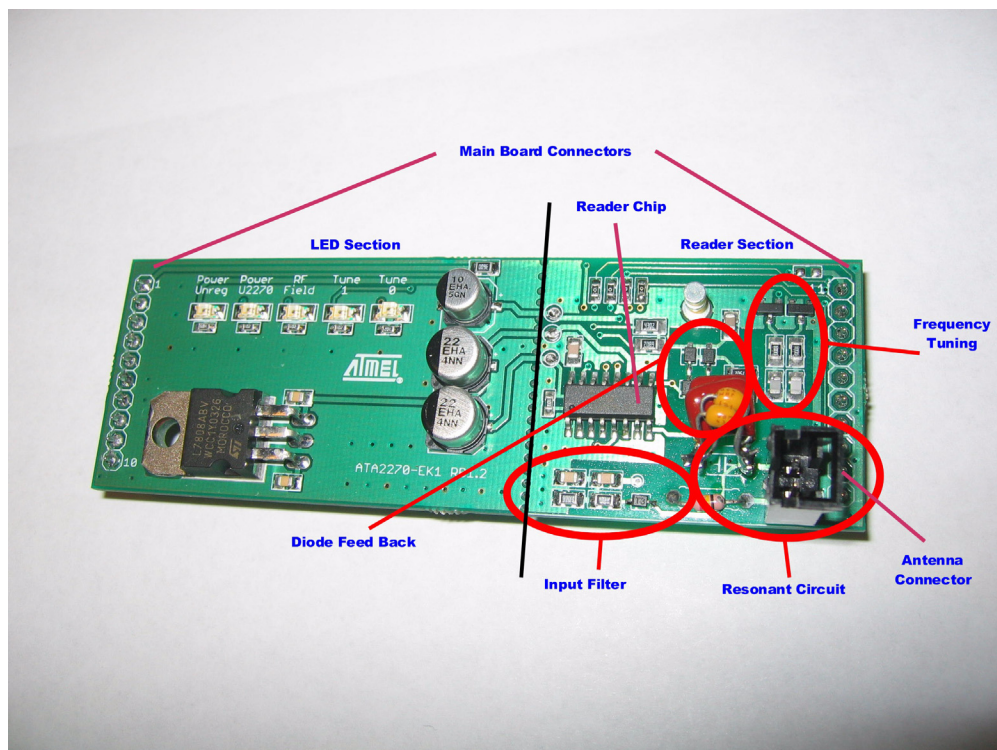


Figure 3-3. ATA2270-EK1 Reader Board

■ LED section

Five status LED's are provided to give a quick visual status of the RFID Reader. The first two LED's show the power supply state. The next three deal with the state of the RF field being generated by the Reader. Viewed from left to right, the LED's show unregulated power, Reader IC power (standby), RF field activity, and two-stage frequency tuning settings.

■ Power section

12V unregulated power is supplied from the MB via the lower left connector. This is then supplied to an 8V regulator and provided to the Reader IC. The reader will source 5V if it is not in the Standby mode. Therefore, there are three power supply rails on the RB and the three test points on the left side of the Chip Section can be used to monitor the voltages.

Also part of this reference design is the ability to run the Reader reference section on one power supply. This can be achieved by adding a zero ohm resistor to the resistor pads located by the top right header row. Then the three test points must be shorted together. A 5 volts supply is applied on the top pin of the right side header coming from the MB which will be used for the reader voltage. This will decrease the effective range of the system due to a lower antenna drive voltage. This is applicable if the Reader reference design is cut out and used to prototype a custom application.

Caution

Do not short the three test points if the reader reference section has not been removed from the main RB!

■ Reader Section

There are four main portions of the Reader reference section of the RB: the antenna resonant circuit, input filter circuit, diode feedback circuit, and frequency tuning circuit.

The Antenna resonant circuit: This circuit sets the self-resonant point for the reader antenna. The resonant LC circuit also allows the antenna voltage to increase above the driving voltage. Resonance is accomplished by adding a series capacitance to the inductance provided by the external antenna coil. Also a series resistance is used to limit the current and set the antenna Q-factor.

A method to tune the antenna circuit is to start with an LC combination and drive this circuit with a square wave from a function generator. Monitor the voltage of the antenna at the Capacitor connection point and attempt to get the peak voltage to occur at 125kHz. If changing the frequency of the function generator higher than 125kHz give a greater voltage, more capacitance is needed. If a lower frequency has greater voltage then there is too much capacitance in the system.

Input filter circuit: The data response from a transponder is modulated directly on the carrier frequency. In order to decode this signal, it must first be “harvested” from the carrier. First a high voltage diode (200V) is used to rectify the signal to a half-wave. Then two resistors provide a charging and discharging path for a capacitor. These work to “harvest” the signal from the peaks of the half-wave. The last capacitor provides high-pass coupling to filter the signal for a data rate.

Diode feedback circuit: In order for maximum efficiency, the antenna should be driven at the self-resonant frequency. This circuit monitors and adjusts the frequency of the oscillator in the Reader IC so that the antenna is being driven at the proper frequency. This allows the antenna circuit to produce the strongest possible RF Field.

This circuit operates as a phase lock loop that works to achieve a 90-degree phase shift between the high and low sides of the antenna voltage. Any phase difference will send current in/out of the by-pass capacitor and RF pin thereby changing the driving frequency of the internal oscillator.

Frequency tuning circuit: The maximum range of communication will be achieved when the resonant frequency of the reader matches the resonant frequency of the transponder. Also higher Q-factors of the antenna, while increasing the range, makes the frequency match even more important. Because the tag antenna is fixed in most cases, this circuit allows trimming of the resonant frequency of the Reader antenna by software control. There are four steps provided in approx 2kHz increments. The current selection is displayed on the status LED's in a binary fashion.



The frequency is tuned by adding capacitance to the resonant circuit. This is accomplished using high voltage (200V) MOSFET devices. Under software control, the capacitor can be connected to ground through the FET. This will lower the resonant frequency of the circuit. With two of these structures, there are four possible combinations to choose between.

- Antenna Coil

Included in the kit is an air-core antenna coil shown in Figure 3-4. This is an external antenna so that a custom antenna can be interfaced with the RB if other antennas are experimented with. This antenna is wound to give an inductance of approx 700uH. If a different antenna is used, it should either meet this number or the capacitors on the RB should be adjusted to make the circuit resonant. The connector is a locking type because of the high voltage differential that will be placed on the antenna.

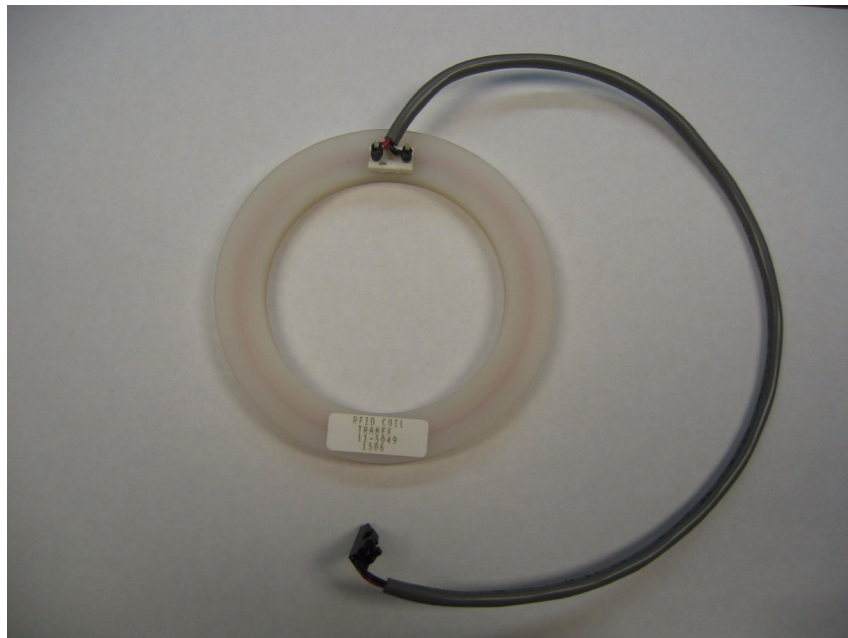


Figure 3-4. Air-Core Antenna

The area of the antenna plays a large factor in the range that the system will achieve. There will always be a trade-off between available area and range required. Also the area the transponder antenna encloses also effects the range of the system. This antenna attempts to achieve a compromise suited for a simple system but is only intended as a reference, not as the ultimate form factor for an antenna.

- Reader board connections

The reader board connector's twenty pins allow the Reader hardware to communicate with the uC. They also supply two potential power rails to the reader board. The functions from the U2270 used are listed in Table 3-5.

Table 3-5. Reader Board Connector Function

Pin			Pin
1	VCC1	VCC2	11
2		OUTPUT ENABLE (OE)	12
3		OUTPUT	13
4		CFE	14
5		STANDBY	15
16			
7		TUNE2	17
8		TUNE1	18
19			
10	GND	GND	20

3.4 125 kHz Transponders

Transponders (Tags), as referred to in this document, consist of the following items: IC, capacitor, and antenna coil. There are several options to purchase these items from Atmel; bare IC's on a wafer all the way to a complete transponder in a plastic package. Included in the kit are several form factors for these transponders. These are not the only options but intended for reference to what can be achieved.

All of the transponders consist of data grouped into Blocks. These blocks contain 32 bits and are displayed in Hex format. It is very important to be aware of the order of these Blocks. When displayed the bits number from 1 to 32 read from left to right.

Table 3-6.

Data BlockX Bit Order									
1	2	3	4	29	30	31	32

■ TK5530

Read only device. The data is programmed at the factory and cannot be modified. Customers can provide Atmel with a custom file to be loaded into the tags if they would like specific numbers, otherwise, Atmel will load a sequential number to the tags. There is a max of 128 bits of data stored in these tags. Different modulation and data rates are available. For size comparison, this transponder is shown with a dime in Figure 3-5.

This kit will support a “default” tag type configured to use RF/32, Manchester, 64 bit data.

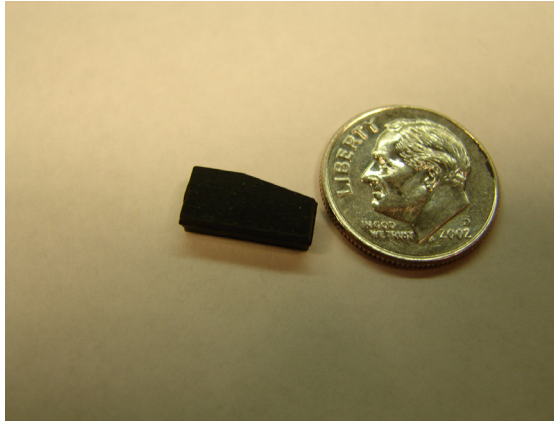


Figure 3-5. TK5530 Transponder

■ TK5551

Read/Write device. This transponder consists of one configuration block and seven data blocks. Each data block stores 32 bits of information for a total data memory of 224 bits. The evaluation kit is set to use only one configuration. This is to ensure that if a tag is configured properly it will be read by the system with minimal problems. If unsure that the tag is configured properly, write the proper configuration using the Write Configuration menu before using the other menu options. For size comparison, this transponder is shown with a dime in Figure 3-6.

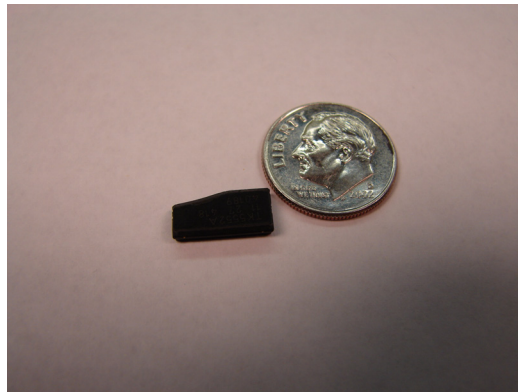


Figure 3-6. TK5551 Transponder

■ T5557 and ATA5567

Read/Write device. This transponder consists of one configuration block, seven data blocks, and two manufacture ID blocks. Each data block stores 32 bits of information for a total programmable memory of 224 bits. The evaluation kit is set to use only one configuration. This is to ensure that if a tag is configured properly it will be read by the system with minimal problems. If unsure that the tag is configured properly, write the proper configuration using the Write Configuration menu before using the other menu options.

The manufacture ID blocks are locked from the factory and can be used as a unique ID to track the tags. The ATA5567, shown in Figures 3-7 and 3-8, is an upgraded version of the T5557.



Figure 3-7. ATA5567 ISO Card



Figure 3-8. ATA5567 Coin Cell

■ ATA5570

Read/Write device. This transponder is a derivative of the T5557 with the addition of a sensor input line. All of the data structures are the same as listed for the T5557. Once configured properly, if the sensor input line sees high impedance with respect to Vss, the tag transmits the data correctly. When low impedance (<100kOhms) is placed on the sensor input, the tag transmits the data inversely.

An ATA5570 card with a push button has been included in the kit to demonstrate the change that will occur when the Sensor line changes state. To view this, place the kit in the continuous read mode by selecting RFID>Read/Write Menu> Auto. Place the card in the field and then press the button. The data displayed should invert once the button has been pressed. An optional PCB is available for more intensive development purposes.

Note: When sending commands to the ATA5570 the sensor line must be in a high impedance state. An optional demo board as shown in Figure 3-9 can be ordered to evaluate this transponder; otherwise the kit only includes sample IC's.

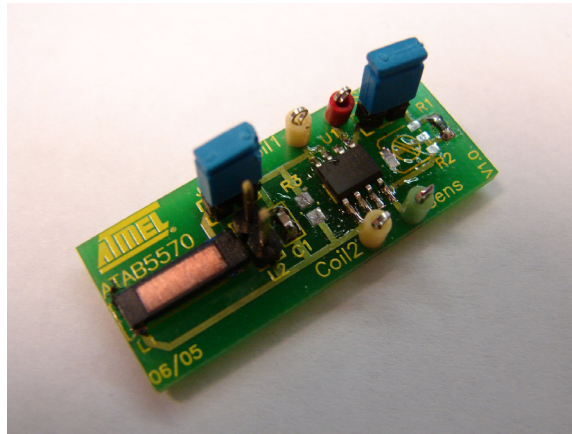


Figure 3-9. Optional ATA5570 Board

■ **ATA5558**

The ATA5558 is one of Atmel's newest 125kHz transponder. This transponder has a larger memory size of 1k bits. Also new with this tag is true anti-collision. The anti-collision feature uses "Interrogator Talk First" and then a tree-walking scheme. The evaluation kit firmware allows the use of up to twelve tags in the field. Also the kit implements a "Loop" feature to easily find tags as they enter/exit the field. Once a tag has been selected, the contents of that tag can be accessed even with the other tags present.

■ **ATA5577**

The ATA5577 is also one of Atmel's newest 125kHz transponder. This transponder is very similar to the ATA5567 mentioned about with the exception of a configurable analog front end. This allows the tag to be configured to work in a variety of circumstances such as a very high Q configuration for example. Also this allows the ATA5577 to have industry leading performance when used in an ISO11784/785 configuration. This device should be considered for all new designs. Full support for this tag is included.



Software Description

This section contains a detailed description of the software furnished with the Evaluation Kit. The menu hierarchy shows the initial settings that should be used.

4.1 Menu Hierarchy

When the Evaluation Kit is first switched on, the Main Menu appears across the top row of the LCD. The Main Menu consists of the following four items: RFID, PC, RTC, and Display. This section looks at these menu items in detail. Entries are shown in parenthesis and for convenience, the initial setting has an asterisk (*) next to it.

4.1.1 RFID

- Select Reader/Tag
 - Reader column (U2270B*)
 - Tags column (x5530/ x5551/ x5552/ x5557/ x5567/ x5577*/ x5570/ x5558)
- Reader Options (U2270B)
 - RF Field – (Off*/On)
 - Output – (Off/On*)
 - Standby – (Off/On*)
 - Ant Tune – (High/ Semi-High/Semi-Low*/Low)
- Tag Options (Will change based on Tag Type)
 - Write column – Pulse-Pause Code timings (x5577)
 - SGap Time (300us to 600us) 400us*
 - Gap Time (100us to 300us) 220us*
 - One Time (300us to 500us) 330us*
 - Zero Time (80us to 250us) 80us*
 - Read column – Minimum and Maximum limits for Manchester times (x5577)
 - Short (us) (50us min, 210us max)*
 - Long (us) (210us min, 350us max)*
 - Term (us) (330us min, 450us max)
- Write Configurations (Yes/No) – If Yes, an attempt will be made to program Block 0 of the selected tag. No verification is done in this step.
- Read/Write Menu (Begins with Search and Select menu for x5558 tag)
 - Write column
 - Write One Block – Edit/write one block
 - Write All Blocks – Edit/write all blocks
 - Write AFE Options – Only x5577
 - Write Tag ID - Only x5558
 - Write Clear – Only x5558
 - Read column

Read Manual – ENTER starts read
Read Auto – Reads until exit (F4 Button)
Read Mfg. ID – Only supported tags
Read AFE Reg – Only x5577
Read Tag ID – Only x5558

■ Animal ID

Write column

Write One - Edit and program tags to meet the ISO 11874/875 protocol

Read column

Read Lite - Reads ISO 11874/875 format Country and National code. Check mark signifies correct CRC.

Read All - Reads ISO 11874/875 formatted data and displays all of the information contained.

4.1.2 PC

- Serial – Connects to RS232 pins. Baud Rate can be changed by moving the joystick UP/DOWN. The baud rate must be match on the PC for proper communication.
- USB – Upgrade Firmware - Allows firmware upgrade through the serial port.
- Bootloader – Press ENTER twice to enter the bootloader. Once in this mode, the firmware can be upgraded using AVR Prog. Pressing the Exit button in AVR Prog or sending an 'E' over the serial port is the only way to exit from this mode.

4.1.3 RTC

- Time – Displays the current time
Pressing ENTER while Time is selected changes time format. Select value and use joystick up/down to change. Save by pressing ENTER.
- Date – Displays the current date
Pressing ENTER while Date is selected changes date format. Select value and use joystick up/down to change. Save by pressing ENTER.

Note: In order for the time and date to remain active and correct, the 3V coin cell battery must be used. Insert the coin cell battery into the receptacle on the underside of the Main Board. Observe proper polarity by orienting the battery so that the plus (+) side is away from the board

4.1.4 Display

- Contrast – Adjust LCD Contrast
- Brightness – Adjust backlighting
- Sound – Turn audio feedback (Off/On*)
- Inverse – Invert LCD colors (Off/On*)

4.2 Using RFID

The menu settings are further explained in the following paragraphs.

4.2.1 Select Reader/Tag Menu



In order to begin evaluation of the Atmel family of RFID devices, a Reader and Tag type must be chosen. Currently Atmel only offers one 125kHz RFID Reader IC (U2270B). This is selected by default. To select a transponder, scroll UP/DOWN using the Joystick. The currently selected tag is indicated by a check mark. To change the selected tag, select it and press the ENTER. The new check mark position shows that the change was successful.

Note: It is very important to choose the desired Reader/Tag combination before proceeding. The other menu options can differ depending on the selections made in this menu.

The selected tag type will be displayed in the header for easy reference in the subsequent menus.

4.2.2 Reader Options Menu

This provides control over the selected Reader hardware. Currently, only the U2270B Reader IC is supported. This menu allows control of the RF field, demodulated output, standby mode, and antenna resonant frequency.

- **RF Field:** This option allows direct control of the generation of the RF field by turning it ON or OFF. Testing of the RF field spectrum, tag response time, etc., can be achieved by using this menu option.
- **Demodulated Output:** The received RF signal is demodulated and placed on the Output pin. The result is that the output line is constantly toggling even if there is not a valid tag in the field. If it is not necessary to provide this to the uC all the time, the Output can be turned OFF until needed.
- **Standby Mode:** For low current consumption the Reader IC can be placed in a standby mode. If turned ON the IC will go into a low power state.
- **Antenna resonant frequency:** This will allow the RF frequency to be adjusted by ~2kHz steps. There are four possible choices. They are labeled to show the direction the frequency is being shifted. This is achieved by switching in of capacitors through software control. The tuning of the RF field is a manual operation and does not automatically choose the best option. For best system performance the resonant frequency of the Reader antenna and tag antennas must be matched. This circuit allow the Reader resonant frequency to be adjusted because the tag side is fixed in most cases.

In all cases, the menu option is selected by moving the Joystick UP/DOWN. When the desired option is selected, change the value by moving the Joystick LEFT/RIGHT. The change is stored in EEPROM and will survive after power is removed.

4.2.3 Tag Timing Options Menu

The timing limits are used in the communication protocol with the transponder. There are two timing limits that are available to most tags, Write and Read.

Write Timings control the downlink communication. This is where the Reader sends commands and/or data to the transponder. The Atmel Reader uses PPC (Pulse-Pause Coding) where the RF Field is modulated by OOK. OOK indicates that the RF Field is switched completely ON or OFF. PPC uses fixed Gaps (RF OFF) to separate the individual data bits. A logic "1" is considered a Long (RF ON) and a "0" is a Short (RF ON) burst of RF Field between two Gaps. Sending a Gap of SGap time starts the Write process. The Write Timings menu allows the actual time value of these to be modified.

Read Timings deal with the uplink communication from the transponder to the Reader. Although many of the Atmel Tags can communicate in other modes, the U2270B (default) Reader can only demodulate AM responses. Also this Evaluation Kit only decodes Manchester data formats (except for Animal ID). Other data formats may be implemented in the future. In Manchester decoding it is important to specify edge-timing limits. There are minimum and maximum limits set for Manchester Short (T) times as well as Manchester Long (2T) times. Some tags also require a sequence terminator-timing limit to synchronize

the incoming data. This will appear in the Read Timing Menu if applicable. To modify a limit, first move UP/DOWN while the limit name is selected. Then move RIGHT/LEFT to select the limit to modify. Last move UP/DOWN to change the limit value. Return to the limit name by moving RIGHT/LEFT again.

These Timing limits are preset to work in most normal operating conditions. If this system is being used in different conditions or if changes have been made, these limits may need to be adjusted. For example, if a custom transponder or Reader Antenna is being used.

Default timings for the different tags are shown in Table 4-1.

Table 4-1. Default Timing Values

Tag Type	Write Timings (us)				Read Timings (us)					
	SGap	Gap	One	Zero	Short Min	Short Max	Long Min	Long Max	Term Min	Term Max
x5530					50	200	200	320		
x5551	350	276	324	80	50	200	200	300	300	450
5557	330	220	370	100	50	200	200	350		
5567	330	220	370	100	50	200	200	350		
5577	400	220	330	80	50	200	200	350		
5570	330	220	370	100	50	200	200	350		
5558	300	100		(ref)120	50	200	200	350		

Note: The Q factor of the antennas in the system play a large roll in the required timing limits.

4.2.3.1 Write Configurations Menu

Most of the Atmel transponders provide a means of configuring the uplink communication by setting a Configuration Block with the appropriate value. The Configuration Block (normally Block 0) specifies the data rate, modulation type, number of blocks returned, synchronization type, and other features the tag is capable of supporting. For the ATA2270-EK1 kit to provide the most reliable communication with the different transponders, the tags must be placed into a fixed configuration. Choosing the Write Configurations Menu and selecting YES will accomplish this. When ENTER is pressed the system will attempt to write the appropriate configuration block data into the selected tag type.

This only needs to be done when the state of the tag is unknown. Do this when first beginning to work with a new tag. If a different configuration is desired, the change must be made in the source code provided on the accompanying CD.

Note: This process contains no verification of success. It is an attempt only. Ensure that a valid tag type is present in the RF Field when performing this step.

4.2.3.2 Read/Write Menu

The primary purpose of this Evaluation Kit is contained in this menu. The menu provides the interface used to store and retrieve information from a passive RFID transponder. If the selected transponder is a read-only device, the choices will be limited to simple retrieval of the stored data. Availability of these



menus is dependent on what the selected transponder supports. The following sections detail the operation of the menu items.

– Write – One Block

This item allows each data block to be written separately. First select the block number to be written by scrolling UP/DOWN with the joystick. The number of data blocks is dependent on the selected tag type.

Once the block number is selected, move the joystick to the RIGHT to edit the data. Each data block consists of thirty-two bits. These are shown in four hex numbers and each nibble (4 bits) can be changed independently but moving the joystick UP/DOWN. Once the data values have been set, press ENTER to return to the Block Number selection.

Pressing ENTER when a block number is selected starts the write procedure. This step performs verification of the data written to the transponder and returns an audio feedback of the result. If the write was successful the system returns a beep. If some error occurs, a buzz will sound to indicate that the data may not have been successfully written. A message window will also pop-up to display the status of the write.

– Write – All Blocks

This menu functions similarly to the Write – One Block with the exception that ALL blocks are visible and able to be modified. The same controls apply for selecting and editing the data. When all data blocks have been set to the desired values, pressing ENTER on ANY of the block labels will start the write sequence. The system will then attempt to write and verify each block sequentially. This will result in a string of audio feedback results equal to the number of data blocks supported by the transponder. A message window will also pop-up to display the status of the write.

– Read – Manual

This is the most basic data retrieval routine. Each time the ENTER button is pressed a read cycle is initiated. This will attempt to demodulate the incoming data signal using the selected tag timings. If this was successful, a beep will sound and the data will be displayed on the LCD. This will be latched until the next read cycle. This is very useful for checking the contents of a transponder and verifying accuracy of the stored data. If a transponder supports more blocks than can be displayed on the LCD, scrolling UP/DOWN with the joystick will change the page number and allow the additional blocks to be seen. The selected page will stay on the display for each subsequent read attempt.

– Read – Auto

The auto routine is designed to allow continuous checking of the transponder. This is useful in finding a hidden transponder or checking the read range of a tag form factor. In this mode the system will continuously loop through a read routine and display the resulting data on the LCD. If there is no tag in the reader field, the display will show all zeros and an audio buzz will signify a failed read attempt. Successful reading of a tag is accompanied by a beep. If a transponder supports more blocks than can be displayed on the LCD, the same scrolling hold true as defined in the Read Manual routine.

- Read – Mfg. ID

If the Atmel transponder supports Traceability data, this menu will allow the system to read these blocks. The controls function the same as with the Read Manual routine. The data is formatted into Manufacture ID and displayed. These can be used to uniquely identify a tag or to provide feedback to Atmel.

Additional Unique features

The ATA5558 transponder includes some additional features, which make the Read/Write Menu different than above. To access the Read/Write Menu, a unique transponder ID must be selected. An additional in-line menu will allow a search routine to identify all the transponders in the field. It is then possible to select one of these tags with which to communicate. All communication starts with a select ID command followed by the specific command needed. This allows the reader to communicate with the selected tag while the other tags remain in the field.

To begin, navigate to RFID>Read/Write Menu>5558 Anticollision. Press ENTER to start the search routine. Once the tags currently located in the field are identified, they will be listed from largest ID value to smallest. Move the joystick to the RIGHT to select a transponder. Moving UP/DOWN will change the currently selected Tag. Press ENTER to move on to the Read/Write Menu. Additionally included is the ability to Read the Tag ID and Write a new Tag ID.

- Read – Tag ID

This menu reads and displays the three blocks of configurable tag ID data. These blocks are used in the anti-collision process to separate the transponders occupying the RF Field. Pressing ENTER starts a new read attempt.

- Write – Tag. ID

The transponder ID used in the anti-collision can be modified. When changing this ID, care should be taken to insure that it remains unique or the system will not function correctly. After choosing the Block to change, use the RIGHT/LEFT button to select the desired data nibble to be changed. Scrolling UP/DOWN will change the value of the selected data. Pressing ENTER anywhere on the block labels will start the Write process. The new Tag ID is then stored as the selected one so that continued communication with the same transponder can occur. Note that the new tag ID is initialized to the previously read Tag ID.

- Read – AFE Reg

The ATA5577 has a configurable Analog Front End and the current settings can be read using this menu option. The settings are broken up into a functional description and displayed in bit values. (except soft mod suffixed with D or A) Scroll UP/DOWN to see all of the settings.

- Read – AFE Reg



The ATA5577 has a configurable Analog Front End and the settings can be changed using this menu option. The data is shown in hex format with the default setting of 9DC00000. Please refer to the datasheet to select new settings for this block.

4.2.3.3 Animal ID

A subset of RFID is the Animal Identification Application. Special formats for this feature are specified in ISO 11784/785 standards. This menu allows transponders that follow these formats to be evaluated. Also an application note describing how to use Atmel RFID products for this application is included in the CD. The ISO standard specifies an operating frequency of 134.2kHz. This evaluation kit operates at 125kHz nominally but can be modified to work at the correct frequency by changing the capacitors in the antenna tuning circuit.

– Read – Lite

All transponders that follow the ISO standards should be able to be read using this menu. This works as a standard Animal ID reader and will continuously look for a tag that meets the ISO 11784/785 format. Once this is found the Country code and National code is displayed. Also CRC checking is preformed and if it is valid a check mark is placed after the National code. This is continuously running until the menu is exited by pressing F4.

Read – All

All transponders that follow the ISO standards should be able to be read using this menu. Pressing ENTER starts a new read process. After the information is decoded, it is formatted and displayed on the LCD. There are two flag bits that are identified and displayed as a yes/no. These are the Animal and Data flags. The country code is displayed in hex and then decimal value. A National Code is shown in hex because of size constraints. The CRC displayed (first in hex then dec) is the decoded value. If this matches the calculated value a check mark will appear after the dec value. Last is the optional Data values displayed in hex format.

Write – One

This will configure certain Atmel transponders in a mode compatible with the ISO Animal ID standards. From this menu it is possible to edit the two flag bits as well as the National code. The Country Code is set to 999d for test tags. The display format is the same as in the Read menu. The UP/DOWN buttons accomplish navigation between the labels. Change the value of the selected label by moving the joystick RIGHT/LEFT. Once all data values have been changed, press ENTER while any label is selected to start the write process (No verification is preformed in this step). Read the Animal ID to verify that the Write was successful.

4.3 Sample Software

All of the source code used to create this evaluation kit is available on the CDROM and can be modified to fit the end application. The initial software modules were written in C using a Codevision compiler. All subsequent software are written in AVR Studio using the WinAVR plugin. The header (*.h) files contain all of the functions that are available. These are the guides that should be used when calling the functions.

The different function blocks are broken out into self-contained modules for easier portability. The most useful modules are the Reader module (rfid_U2270.c/h) and the Transponder modules (rfid_x5551.c/h, rfid_x5557.c/h, etc).

4.3.1 Code Examples

The following are two examples of how to use the software modules to achieve a read a tag then write a block of data to the tag. The appropriate .c and .h files should be included to support the readers and tags referenced in the code below.

```
*****
unsigned char sBlockDat[9] = "00000000";
unsigned char *sBlockDatPtr;
unsigned char *cDatPtr;
unsigned char *choldDatPtr;
unsigned char startBlock = 1, endBlock = 31;

//**** Check selected tag and configure appropriate number of Blocks ****//
if(Target_Tag == 58){startBlock = 0;}
else if(Target_Tag == 30){endBlock = 2;}
else{endBlock = 7;}

sBlockDatPtr = &sBlockDat[0];
strncpyf(sBlockDatPtr,resetBlock,8);
ioActive = 0;
if(Target_Reader == 70)
{
if(Target_Tag == 51){rError = U2270_Read555xTerm(Target_Tag, &cDatPtr,
224);}
else if(Target_Tag == 30){rError = U2270_ReadHeader(Target_Tag, &cDatPtr,
64);}
else if(Target_Tag == 57 || Target_Tag == 67 || Target_Tag == 70)
{rError = U2270_Read5557Term(Target_Tag, &cDatPtr, 224);}
else if(Target_Tag == 58){rError = U2270_Read5558Data(&cDatPtr, 1024);}
choldDatPtr = cDatPtr
}
ioActive = 1;
*****
```

```

*****
unsigned char cBlockSel = 1;
unsigned char sBlockDat[9] = "00000000";
unsigned char *sBlockDatPtr;
unsigned char cBlockDat[4] = {0};
unsigned char WRbuffer[6] = {0};
unsigned char startBlock = 1, endBlock = 31;

if(Target_Tag == 58){startBlock = 0; }
else{endBlock = 7;}

ioActive = 0;
if(Target_Tag == 51){T5551_WriteBlock(Target_Reader, &cBlockDat[0],
cBlockSel, 1);}
else if(Target_Tag == 57){T5557_WriteBlock(Target_Reader, &cBlockDat[0],
cBlockSel, 1);}
else if(Target_Tag == 67){T5567_WriteBlock(Target_Reader, &cBlockDat[0],
cBlockSel, 1);}
else if(Target_Tag == 70){T5570_WriteBlock(Target_Reader, &cBlockDat[0],
cBlockSel, 1);}
else if(Target_Tag == 58)
{
WRbuffer[0]=0x80;
T5558_WriteCommand(Target_Reader, &WRbuffer[0], 6);
delay_ms(2);
PORTF |= 0x00;
WRbuffer[0]=0x77;
WRbuffer[1]=0x80;
T5558_WriteCommand(Target_Reader, &WRbuffer[0], 44);
delay_ms(2);
PORTF |= 0x00;
T5558_WriteBlock(Target_Reader, &cBlockDat[0], cBlockSel, 1);
delay_ms(2);
}
ioActive = 1;
*****

```

4.3.2 Programming Guide

Atmel encourages the use of this kit to develop a prototype platform for evaluation of the intended application. The kit accepts two very common programming interfaces, ISP and JTAG.

ISP is a downloading method where only six I/O lines are needed. The provided header works with the ATSTK500 as well as the AVR ISP In-System Programmer. Both of these are available from Atmel or



distributors for very low cost program development. To program the flash memory and the EEPROM, first connect the programming tool to the MB using a six-pin ribbon connector. Make sure that proper orientation is maintained by aligning pin1. The files types accepted use Intel Hex format.

To program a hex file into the target AVR device, select "Program AVR" and then "Connect..." from the "Tools" menu in AVR Studio. Once AVR Studio has been opened, connect to the STK500 or AVRISP by selecting "STK500 or AVRISP" in the Platform List. Then select "Connect...". The driver for the STK500 and AVRISP is then started, and the STK500 dialog should appear. Note that the system supports other programming platforms as well, like the JTAGICE or the JTAGICE mkII.

Then select the AVR target device from the pull-down menu on the "Program" tab and locate the Intel-hex file to download. Select the "program" button. Repeat for the EEPROM section.

The same steps apply when using the JTAGICE MKII.

The JTAG Platform allows more control during software development by allowing real-time debugging of the source code. The JTAGICE MKII supports setting breakpoints and stepping through the code being executed on the target micro. This is very useful for a more complex software project such as this one.

4.3.3 Fuse Settings:

Fuse bits must be set properly for the kit to function. The only fuse bits that should be set are listed below.

- JTAG Interface Enabled; (JTAGEN=0)
- Serial program downloading (SPI) enabled; (SPIEN=0)
- Boot Flash section size=1024 words Boot start address=\$FC00; (BOOTSZ=10)
- Boot Reset vector Enabled (default address = \$0000; (BootRST=0)Brown-out detection level at VCC=2.7V; (BODLEVEL=1)
- Int. RC OSC. 8MHz; Start-up time; 6CK + 64ms; (CKSEL=0100 SUT=10)

All others should be unchecked.



Section 5

Troubleshooting

Problems and their solution is shown in the following Troubleshooting Tables

Table 5-1. Troubleshooting Main Board

Problem	Reason	Solution
Power LED not on	Power supply not connected	Provide 9-16V to the MB power plug
	Power Switch not on	Move Switch to left
LCD Blank	LCD reset line hung	Remove power plug. Apply power. Move Switch to left
	Power shut off	See "Power LED not on"
	LCD ribbon cable disconnected	Remove screws and check ribbon cable connector
	Contrast set incorrectly	Press Reset. Move Joystick left 3 times. Press Enter. Move the Joystick LEFT/RIGHT and watch for change.
		Re-flash EEPROM with initial values
	Software not executing correctly	Switch power off. Remove power supply. Apply power. Switch power on.
		Press reset button.
		Re-flash Program and EEPROM with initial files
Fuse settings incorrect	See "Fuse Settings"	
Sound not working	Sound turned off	Check Display>Sound and verify turned ON
	I/O line disconnected	Check R8 populated with 0 ohm
RTC not correct	Battery dead	The kit will not keep proper time after power is removed if the battery is dead. Replace. Always use the power switch before removing power supply to conserve battery life.
	Fuse settings incorrect	See "Fuse Settings"
Re-flash of Memory did not work	Power not connected	Power must be supplied for programming
	Verify source code version	Check for latest version on the Atmel Web Site
	Fuse settings incorrect	See "Fuse Settings"
	AVR Tools not connected properly	Check the help files on AVR Studio

Table 5-2. Troubleshooting Reader Board

Problem	Reason	Solution
Power LED's not on	Power supply not connected	Verify RB correctly attached to MB
	Reader is in standby	Set Standby to OFF in Reader Options>Standby
RF Field not active	RF field turned off	Check Reader Options>RF Field setting
	Antenna not connected	Connect included antenna
	Antenna shorted	Verify that the two antenna leads are not shorted
Cannot read from tag	Read range seems very short	If the range seems to be extremely short, please connect a lead from an Earth ground to the ground turrets on the reader hardware. It is possible that the power supply is too noisy in that location and a Earth ground connection should clean this up.
	Antenna not connected or tuned	Check antenna connection and verify that the antenna is transmitting the proper frequency using an oscilloscope.
	Antenna voltage not sufficient for attempted range	Move the tag closer to the antenna. Verify that the voltage on the antenna (cap side) is ~200V
	Antenna orientation incorrect	The antenna windings of both tag and reader must be parallel to each other. With the plastic transponders this means the tag will be perpendicular to the plane of the reader antenna
	Object or radiator causing interference	The system should not be used on or around a metal surface. Also any devices transmitting at 125kHz will cause reading problems.
	Wrong tag selected in Select Reader/Tag menu	Select correct tag.
	Tag is configured incorrectly	Program the correct configuration using the Write Configurations menu
	IF this does not fix the problem it is possible the tag has been locked	
	Multiple tag present in the field	This system does not currently support multiple tags in the field. Verify only one tag is within range of the reader system unless using ATA5558
	Incorrect timing limits	Reset timing limits to default value listed in Table x
	Re-flash EEPROM with initial values	
	Output not enabled	Turn output ON under "Reader Options" menu
Cannot write to tag	Can not access tag	Verify that tag can be read. Use troubleshooting above.
	Tag has been locked	Not possible to unlock tag
	Tag is read only	Not possible to write to tag

Table 5-2. Troubleshooting Reader Board

Problem	Reason	Solution
Serial Port Connection	Can not communicate with kit	Check that correct COM port is used. Check that PC and Eval Kit baud rate is matched. Try a slower baud rate.
	Kit does not accept commands	Verify that the correct command format described in the Serial API doc is used. Try simple "cmsnd0032beep" for a auditory verification.
	Problems using Hyperterminal	Make sure that "echo typed characters local", "send line end with line feeds", and "append line feeds to incoming line ends" are active for readability. Verify COM port setup with NO parity or flow control.
	Entered Bootloader accidentally and can't exit	Use AVR Prog (AVR Studio>Tools) to send the exit command. Send an upper case "E" using HyperTerminal.



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