Personal Identification Credential System (PICS)

Theory of Operation

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1.0 Glossary

PIC - Personal Identification Credential – handheld identification unit incorporating biometric sensor and Radio Frequency (RF) link

PICS - Personal Identification Credential System

PICS Enrollment Station – Enrollment subsystem that assigns a PIC to an individual

PICS Reader – Interrogation unit that communicates with the PIC and is interfaced with a local access control system

2.0 Background

The PICS is a biometric-enabled access control system. The system provides positive user verification by incorporating a fingerprint sensor and Radio Frequency Identification (RFID) technology for access control.

The Personal Identification Credential (PIC) handheld unit and system have been developed for this access control. The PIC is a device issued to authorized personnel and used for control of vehicular traffic in a fashion similar to electronic toll technology.

3.0 System Description

The PICS consists of multiple handheld PICs, fixed location PICS Reader(s) and PICS Enrollment Station(s), as shown in Figure 3-1. Each PIC will be uniquely assigned to an individual. The PICS Enrollment Station, consisting of a fingerprint sensor, PIC loader, personal computer and enrollment software, will be used to capture the individual's fingerprint(s). The Enrollment Station then will be used to download the individual's unique data into his or her PIC and enter the individual into the system database. The PICS Reader, consisting of an RF module, antenna, and computer components with communication software, will be located at the secured gate of a base or at a secured door. The Reader will communicate with individual PICs one at a time when each is within antenna range.

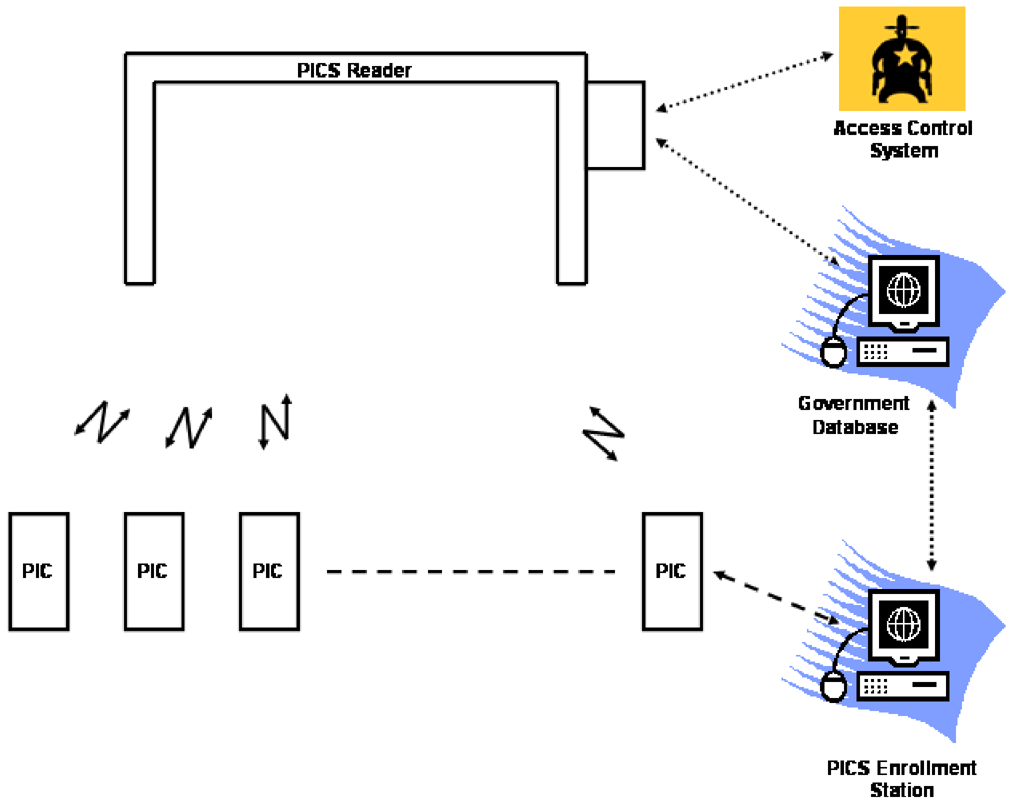

Figure 3-1. PICS Components

The PIC will be used to gain access to secure areas while being handheld by the individual in either a stationary position (on foot to enter through a secure door or gate) or while moving in a vehicle (at speeds up to 5 mph). The user, upon approaching a secure area checkpoint, will place his or her enrolled thumb or finger on the PIC fingerprint sensing element. This then will activate the PIC, which will begin the fingerprint verification process. The PIC incorporates visual and audio feedback to the user for the purpose of alerting the user of success or failure in the verification process. In the event of failure, the typical response of the user would be to reapply the fingertip to capture a better image. Once the PIC has verified the fingerprint and notified the user via built-in visual and audio cues, the PIC will begin checking for an interrogation message from the Reader.

When the PIC receives the interrogation message, it will respond with a unique digital identification number (DIN) that the Reader will use to verify the PIC. The Reader then will look up the PIC in a locally stored database and send a verification confirmation message back to the PIC. The PIC then may notify the user that he or she is cleared to proceed. Optionally, the Reader will be able to interrogate the PIC for additional information, in order to increase the reliability of the verification.

Figure 3-2 depicts the PICS Reader integrated with the existing Smart Gate. A directional antenna mounted from the side of each vehicle path is directed such that vehicles approaching the interrogation field see very little RF energy from the Reader's transmitter. The output power from the Reader's transmitter also is reduced to provide just enough power to communicate with a PIC that is within the interrogation field.

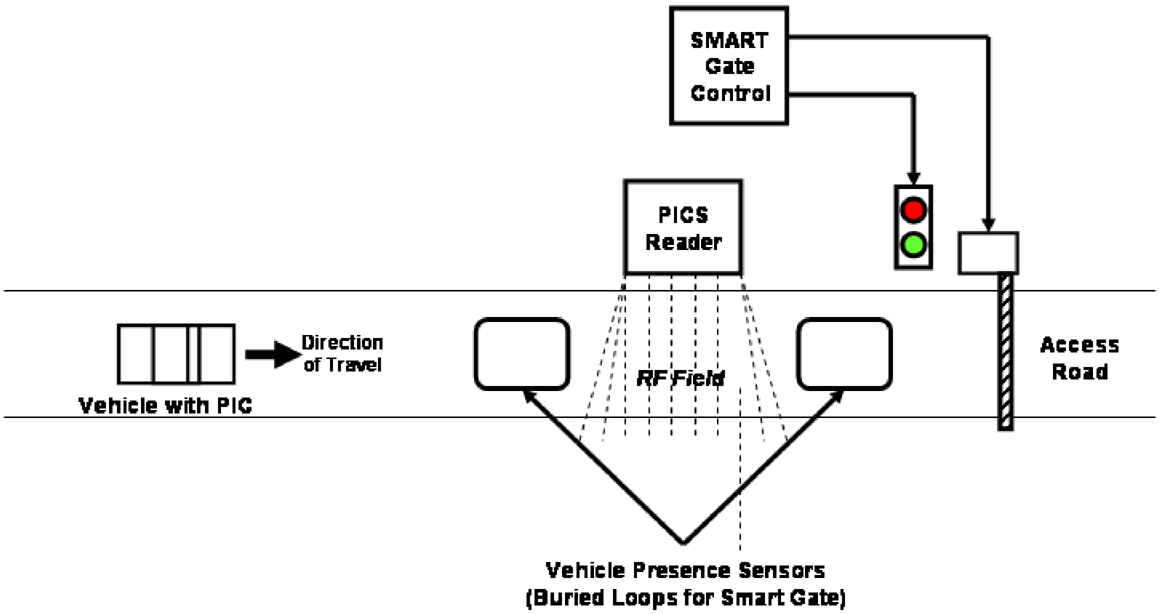

Figure 3-2. PICS Reader Physical Layout

The typical scenario will be that a PICS user activates his or her PIC immediately before entering the PICS Reader RF field. After 1 to 2 seconds, the PIC notifies the user of the success or failure of the fingerprint verification. The user will need to re-verify in the event of a failure. The PICS Reader then begins communicating with the PIC and alerts the Smart Gate control system once the confirmation process has been completed. The entire process should take less than 1 second under normal circumstances. During the communication process, the PIC must identify itself, send a validation message, allow the Reader sufficient time to look up the PIC in the database, and then receive a confirmation message from the Reader. In order to minimize the time lost to communication, messages in this mode will be kept very short (most likely 20 to 50 bytes). Once the PIC is activated and verifies a fingerprint, there is only a period of approximately 5 seconds for the PIC to receive a query from the PICS Reader prior to the PIC timing out and turning off.

During enrollment, the user activates the PIC by placing a finger on the sensor. The initial fingerprint reading will be rejected, but while processing, the PIC will receive a message to put it in enrollment mode. In this mode, the PIC will collect the fingerprint data and pass it on to the Enrollment Station.

4.0 Detail Descriptions

4.1 PIC Circuit

The PIC handheld unit contains batteries, 2 DC-DC switching converters, an TI Digital Signal Processor (12MHz crystal) with flash memory EEProm and SDRAM, an LED, a compact audio transducer, and a fingerprint sensor as well as the Chipcon RF Low Power Chip Transceiver and a very small helical monopole antenna (-1dB typical gain relative to isotropic). See Figure 4-1 for the detailed block diagram.

The two step-up/down DC-DC converters are used to provide 3.3V and 2.5V from the batteries. The battery is a Varta, Lithium Ion 3.8 V, 1000mAh unit. The circuit provides for a low battery indication at approximately 3.2V. The PWR ON input is held low until the slide-operated switch is closed when the slide (door) over the fingerprint sensor is opened. This enables the DC-DC converters which power up the PIC at that time. The microprocessor then holds the DC-DC converters enabled for the duration required to complete operations. Each of the DC-DC converters is an integrated switching regulator for step-up and linear regulator for step-down. The switching frequency of the DC-DC converters in step-up mode is variable, dependent on the load current and input voltage. There is a constant 1us off time and variable on time – up to 4us maximum when the switching regulator is operating. The 3.3V DC-DC converter is the only one that should operate in the step-up mode when the input voltage is in the range near the low battery indication. The 2.5V DC-DC converter should always operate in step-down mode.

The 12MHz crystal connected to the microprocessor is always oscillating after power-up stabilization. The microprocessor is used to control the communications through the RF module, the fingerprint sensor algorithm, serial ID query, holding power enabled for the PIC, and powering down the PIC after the required communications are complete. The microprocessor program is written into the flash memory along with the enrolled fingerprint data. This program is moved to SDRAM on power-up and executed from the SDRAM. The microprocessor operates the bi-color LED for visual indications to the user. The microprocessor uses the compact audio transducer to provide audio cues to the user.

The microprocessor produces the clock signal to the fingerprint sensor The microprocessor has the capability to disable the clock for lower power dissipation. This capability is not presently used. The fingerprint sensor uses a drive ring and receiving array to detect a finger, stores this data, and outputs the data when read by the microprocessor. The fingerprint sensor stores only one image at any time. The sensor also provides an indication regarding the image quality.

The Chipcon RF Chip uses an external 14.7456 MHz crystal. The receive oscillator (Cfreq – 150 KHz) is turned on when the module is enabled for receive and the transmit oscillator is turned on when the module is enabled for transmit. The transmit center frequency is 915.0 MHz ± 50KHz. The RF module uses Frequency Shift Key (FSK) modulation with TXDATA input at 38.4Kbps. The deviation from the center frequency is 90 to 130KHz using 0 to 3.3V TXDATA – this application has TXDATA input of 0 to 3.3V. The transmit output power of the RF module is 1mW maximum. The PIC uses the maximum transmit output power. The receive Local Oscillator (LO) frequency is Cf – 150 KHz. The receive circuit intermediate frequency (IF) is. The RF chip has an input signal for a powered down mode which is not being used by the software.

The antenna used is an extremely compact ¼ wave helical monopole antenna set to match a 50 ohm load. It has a typical gain of -1dBi.

The printed circuit board (PCB) used, approximately 1.5 inches by 3 inches, has a ground plane throughout the board on layer 2 and a 3.3V power plane throughout the board on layer 5.

4.2 PICS Enrollment Station Circuit

The PICS Enrollment Station is powered either from an external user-provided AC/DC adapter or an internal battery, contains a low-dropout (LDO) linear regulator, an LED, an RS-232 transceiver, the Chipcon 915MHz RF Chip with built-in micro-controller and a surface mount (SMT) planar antenna (-1dB typical gain relative to isotropic). The Enrollment Station is operated from an external personal computer (PC) provided by the user operating with Enrollment Station software. See Figure 4-2 for the detailed block diagram.

The LDO linear regulator is designed to accept power from an external AC/DC adapter that provides 9 to 16VDC or to use a 9V battery inserted into the case. The regulator output is 5V.

The 14.7456 MHz crystal for Chipcon CC1010 is always oscillating after power-up stabilization. The built-in microcontroller is a version of an 80C51. It is used to enable transmit or receive mode and to send transmit data. Transmit mode is enabled when receive mode is disabled and vice versa. The microcontroller is programmed via the RS-232 interface and contains internal flash memory for the program. The microcontroller drives the LED for visual feedback to the user.

The RS-232 transceiver is used by the RF module to send the received data to the external PC and is also used to receive data for control and transmit from the external PC.

The Chipcon 915 MHz RF chip is the same part and has the same operation as described in section 4.1. The antenna used is a SMT planar (loop) type with a typical gain of -1dBi.

The PCB used, approximately 3.3 inches by 3.9 inches, has a ground plane throughout the board with the exception of the area from the back of the antenna to the front. This area is one edge of the PCB. There are no other components or planes in this area.

4.3 PICS Reader Module Circuit

The PICS Reader module is powered by 5VDC provided from an external user-provided AC/DC power supply or adapter. The Reader module contains the Chipcon 915 MHz RF chip with an RS-232 transceiver. The Reader module is operated from an external PC provided by the user that outputs transmit data. The Chipcon 915 MHz RF Chip is the same part and has the same operation as described in section 4.1. See Figure 4-3 for the detailed block diagram.

The antenna for the Reader module is a directional log periodic antenna with a 12.4dBd 35 degree (14.5dBi) gain and is connected to the module through a cable. The antenna cable has a spark-gap surge arrestor inserted between the module and the antenna. Due to the gain of this antenna, there is attenuation between the RF module and the antenna - we have been experimenting with different values and checking the operation of the system (this is an item that the value used may need to be changed during testing). There is also an adjustment provided on the transmit power via a potentiometer that may be used to reduce the power during testing.

The PCB used, approximately 2.75 inches by 4 inches, has a ground plane throughout the board.

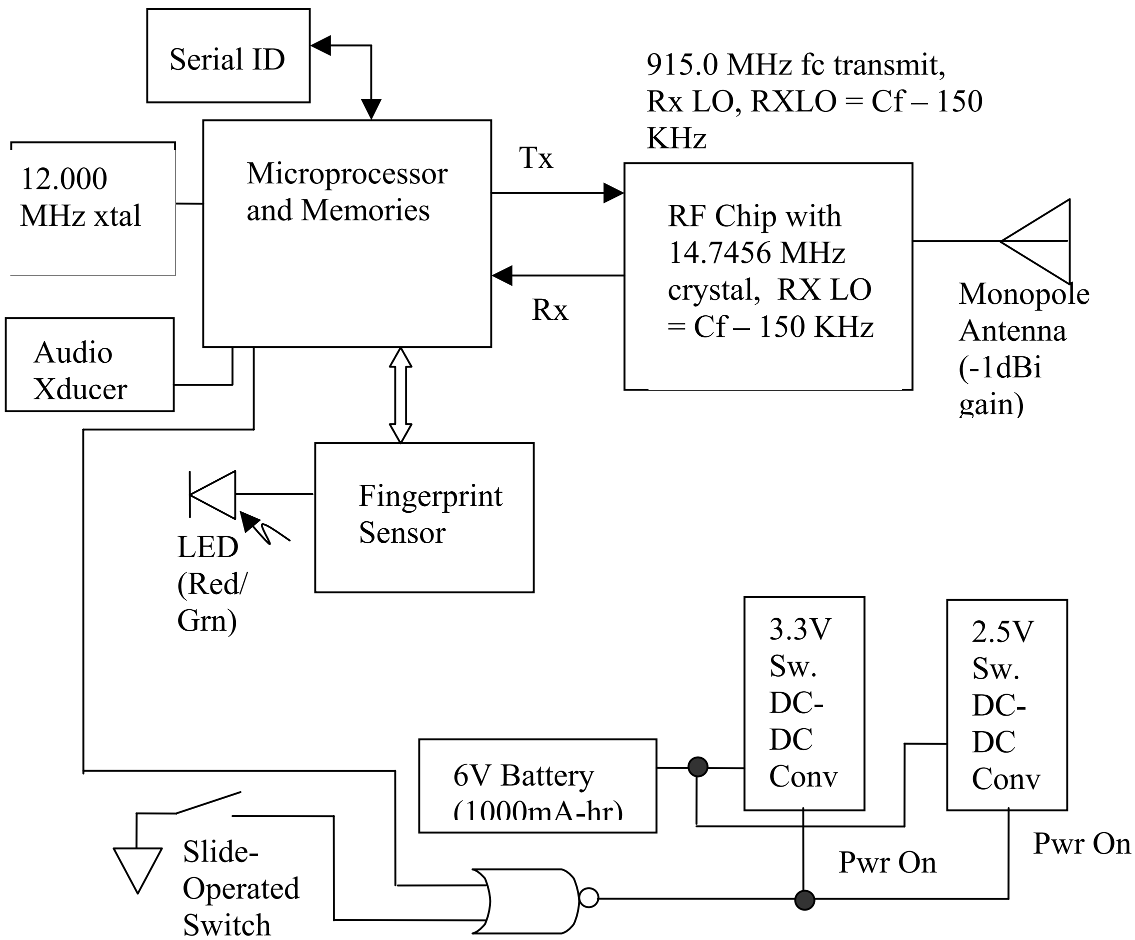

Figure 4-1. PIC Detailed Block Diagram

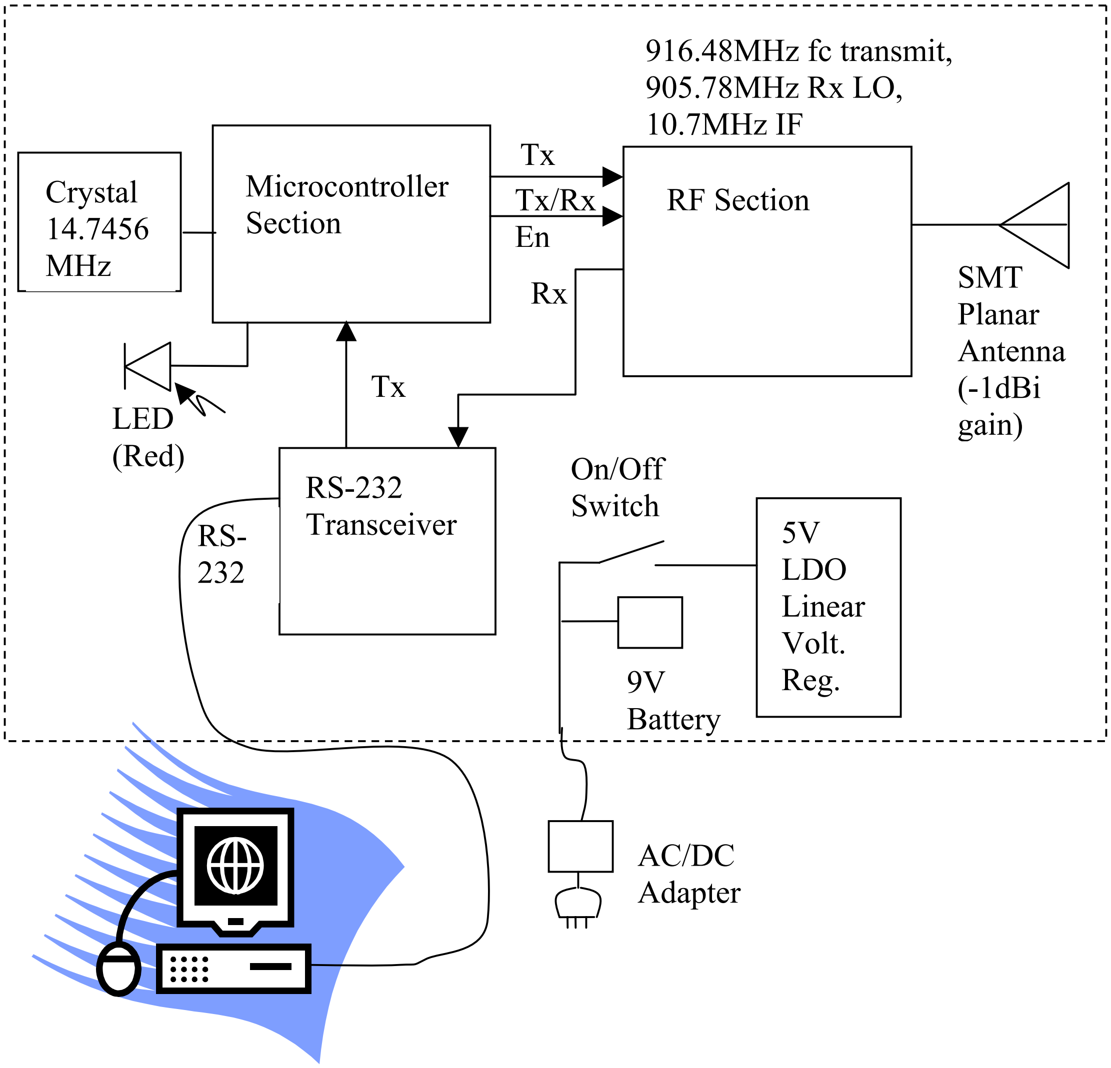

Figure 4-2. PICS Enrollment Station Detailed Block Diagram

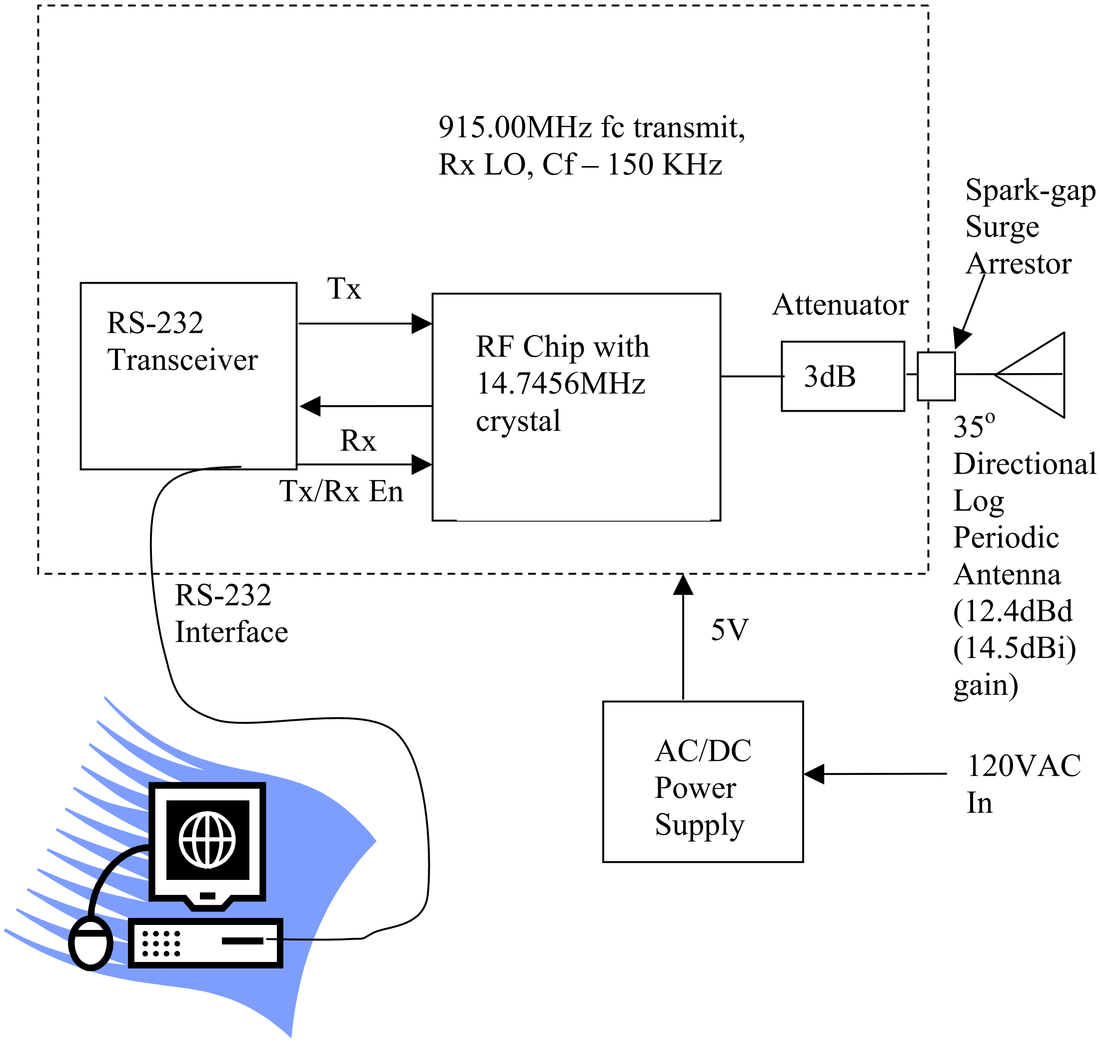

Figure 4-3. PICS Reader Module Detailed Block Diagram