iso7816_vcc.asm
January 16, 2005

Web: http://www.smartcache.net/
E-mail: info@smartcache.net

Introduction

iso7816_vcc.asm implements an interface between an RS-232 serial port and an ISO 7816 smart card, and is targeted for the Atmel AT90S2313 microcontroller in a development terminal. iso7816_vcc uses the Pulse Width Modulation (PWM) mode of Timer/Counter1 in the Atmel microcontroller to generate the voltage supplied to the ISO VCC and CLK contacts of the smart card.

Pulse Width Modulation

The PWM waveform generated by the microcontroller is a periodic pulse train that varies between 0 volts and V_{CC} (the supply voltage applied to the microcontroller, nominally 5 volts). iso7816_vcc uses a value stored in EEPROM to program the PWM TOP value, which defines the pulse width; once this value is programmed, it is never changed (and consequently, the DC voltage applied to the ISO VCC and CLK contacts, as explained below, is never changed).

A periodic signal such as a pulse train can be expressed as the sum of a DC value and a series of sinusoids with frequencies that are integer multiples (i.e., harmonics) of the frequency of the pulse train. The frequency of the pulse train is known as the fundamental frequency. Passing a periodic pulse train through an ideal low-pass filter that has a cutoff frequency below that of the fundamental frequency results in a purely DC signal. In practice, a suitable DC signal can be obtained using a simple RC low-pass filter with an appropriate 3 dB cutoff frequency.

The magnitude of the DC component, C_0, of a periodic rectangular pulse train that varies in amplitude between 0 and A is given by the following equation:

$$C_0 = A\tau/T$$

where A is the pulse amplitude (V_{CC}), τ is the pulse width, and T is the period. For a periodic pulse train, the period T is constant, so the magnitude of the DC component C_0 is directly proportional to the pulse width.

In development terminals, the PWM waveform generated on output pin PB3 of the Atmel microcontroller is input into an RC low-pass filter, then into an operational amplifier configured as a voltage follower (unity gain). The output of the operational amplifier is applied to the ISO VCC and CLK contacts via a 74HC4053 analog multiplexer/demultiplexer[1].

ISO 7816 VCC Ranges

The ISO 7816 standard specifies minimum and maximum values for VCC under normal operating conditions. These values are a function of the class of the smart

[1] The 74HC4053 analog multiplexer/demultiplexer contains 6 switches whose outputs are connected in pairs, thus implementing a triple 2 channel multiplexer, or the equivalent of 3 single-pole-double throw (SPDT) configurations. In a development terminal, these SPDT switches are used to apply either V_{CC} or the filtered PWM to the ISO VCC contact. The SPDT switches are also used to apply either V_{CC} or the filtered PWM in the pulsed signal that is applied to the ISO CLK contact. The switches, and consequently the voltage applied to the ISO VCC and CLK contacts, are entirely under the control of the program running on the Atmel microcontroller.

card, as defined by ISO 7816-3. For Class A smart cards, the specified range is 4.5 to 5.5 volts. For Class B smart cards, the specified range is 2.7 to 3.3 volts.

ACOS1, manufactured by Advanced Card Systems, is an example of a Class A smart card. ASECard Crypto, manufactured by Athena Smartcard Solutions, is an example of a smart card that supports both Class A and Class B operating ranges.

Operating Ranges in Specifications and Standards
Specifications and standards specify operating ranges to insure interoperability between products produced by different manufacturers. For example, if one manufacturer produces a smart card reader that conforms to the ISO 7816 operating ranges, and another manufacturer produces a smart card that conforms to the ISO 7816 operating ranges, then compliance to the standard by both manufacturers implies that the smart card should function in the smart card reader.

However, manufacturers typically exceed the operating ranges of specifications and standards, and for good reasons. In general, it is not considered a good design practice to design a product that only operates within the operating range specified in a specification or standard. It makes no sense to design such a product if choosing to use one part that results in a conservative operating range over another part that results in a marginal operating range makes sense, especially when there is little to no cost difference between the two parts. Nor does it make sense to design such a product if the engineering effort alone would be unnecessarily overwhelming. Nor does it make sense to design such a product if it cannot be reasonably assured that, for example, accuracy limitations inherent in test and measurement equipment have not been fully taken into account.

Often, exceeding the operating ranges of specifications and standards makes sense from the standpoint of interoperability. For example, suppose Manufacturer A produces a smart card reader that supplies a voltage of 4.49 volts to the VCC contact of the smart card; Manufacturer B produces a smart card that functions from 3.75 to 5.5 volts; and Manufacturer C produces a smart card that functions only within the specified operating range of 4.50 to 5.50 volts. If you were stuck with the smart card reader from Manufacturer A, which smart card would you choose?

Uses for iso7816_vcc
You can use iso7816_vcc to determine the lower bound of the VCC operating range of an ISO 7816 smart card. My research shows that an ACOS1 8K ISO 7816 smart card continues to operate at a VCC supply voltage of 3.75 volts. This is 25% below the nominal VCC supply voltage of 5 volts. ISO 7816 specifies a lower bound of 4.5 volts, or 10% below the nominal VCC supply voltage of 5 volts.

Figure 1 shows an ACOS1 8K ISO 7816 smart card operating at approximately 3.75 volts in a Whiteviper unlooper that is programmed with iso7816_vcc (EEPROM TOP value 0xC6). SmartCache is interfacing with the unlooper and running in Test mode (continuous reads of the smart card). Notice the activity LEDs.

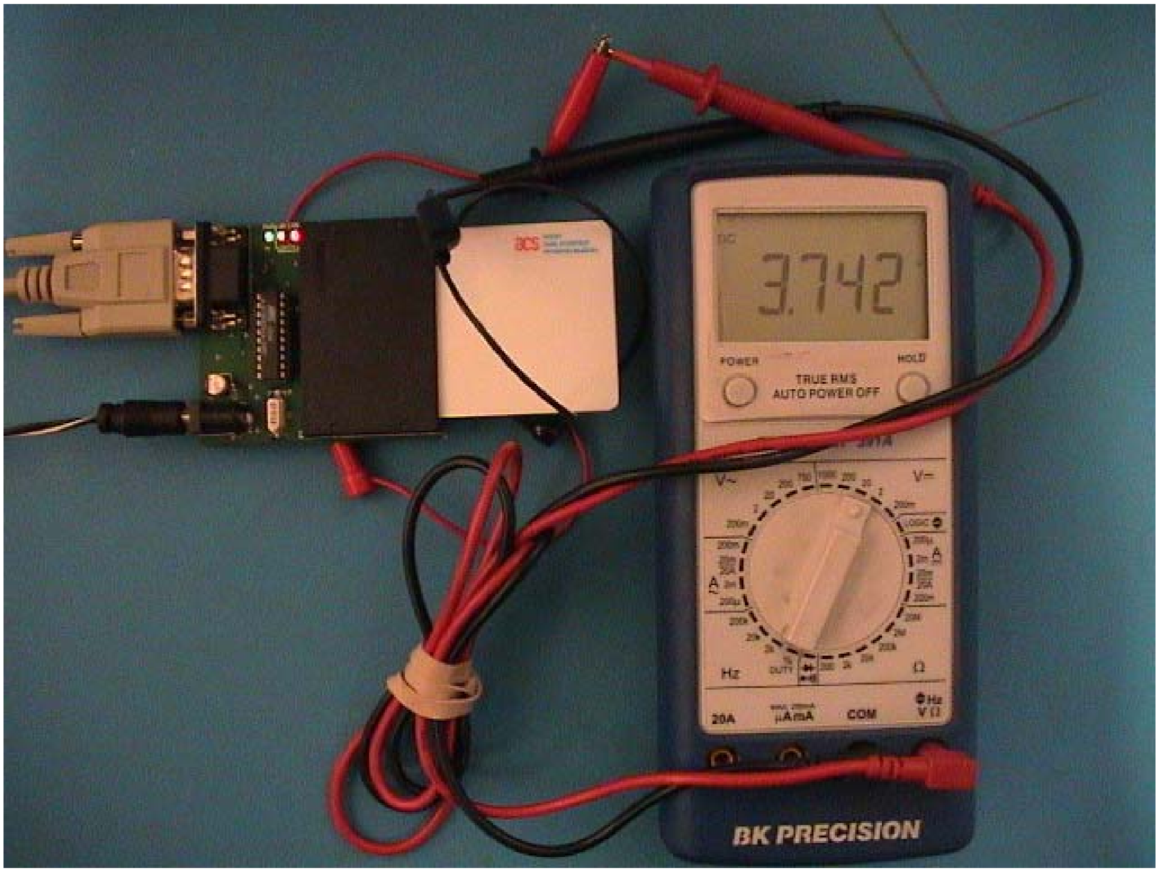

Figure 1: ACOS1 8K ISO 7816 smart card in Whiteviper unlooper running iso7816_vcc. The digital multimeter is displaying the DC voltage being supplied across the VCC and GND contacts of the smart card slot.

You can also use iso7816_vcc to make a development terminal interface with an ISO 7816 Class B smart card at the nominal Class B VCC supply voltage of 3.0 volts. Figure 2 shows an ASECard Crypto ISO 7816 Class B smart card operating at approximately 3.0 volts in a Whiteviper unlooper that is programmed with iso7816_vcc (EEPROM TOP value 0x9B). SmartCache is interfacing with the unlooper and running in ATR Test mode[2] (continuous resets of the smart card). Notice the red read LED is on, indicating that the smart card is responding with its ATR. Figure 3 shows the same setup looking at the bottom of the unlooper.

[2] This feature will be available in SmartCache 2.1. It simply automates the process of pressing the Reset button over and over. It was implemented to facilitate a basic level of testing with smart cards other than ACOS1.

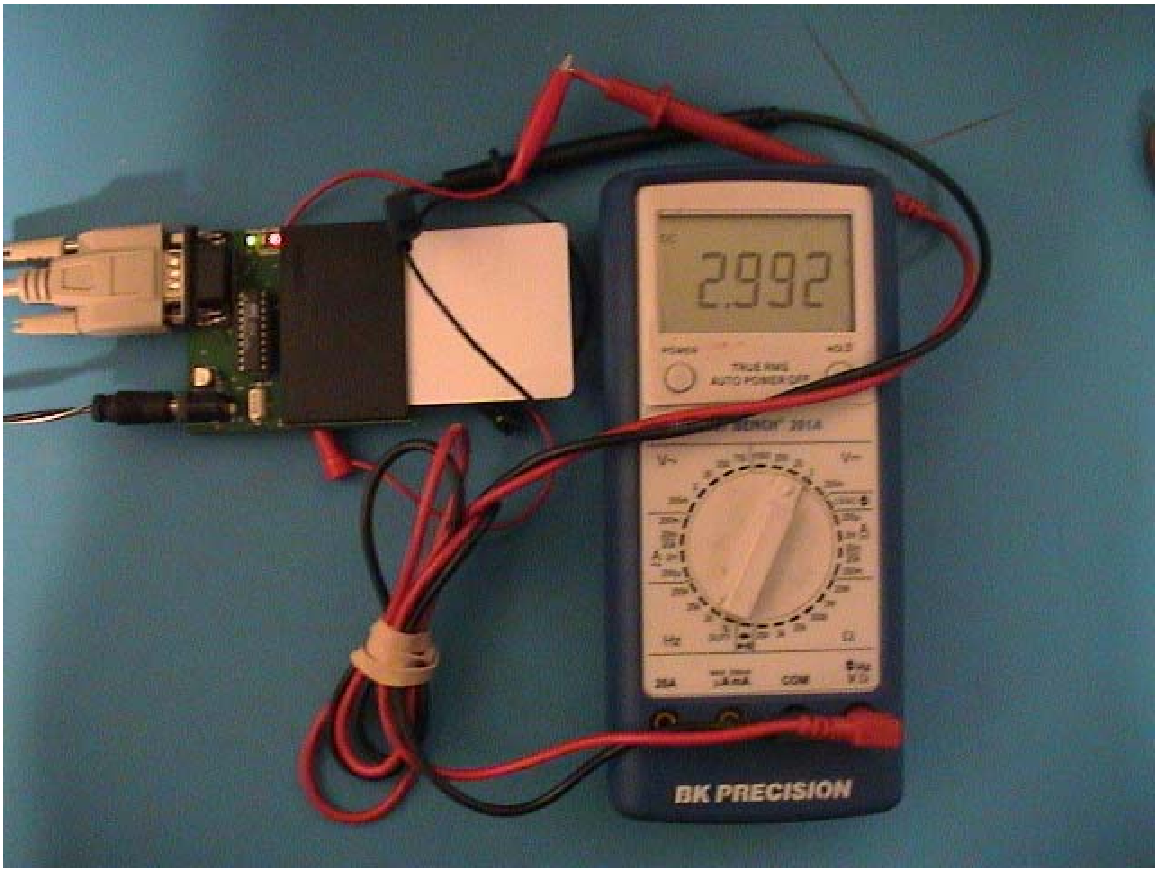

Figure 2: Top view of ASECard Crypto ISO 7816 Class B smart card in Whiteviper unlooper running iso7816_vcc. The digital multimeter is displaying the DC voltage being supplied across the VCC and GND contacts of the smart card slot.

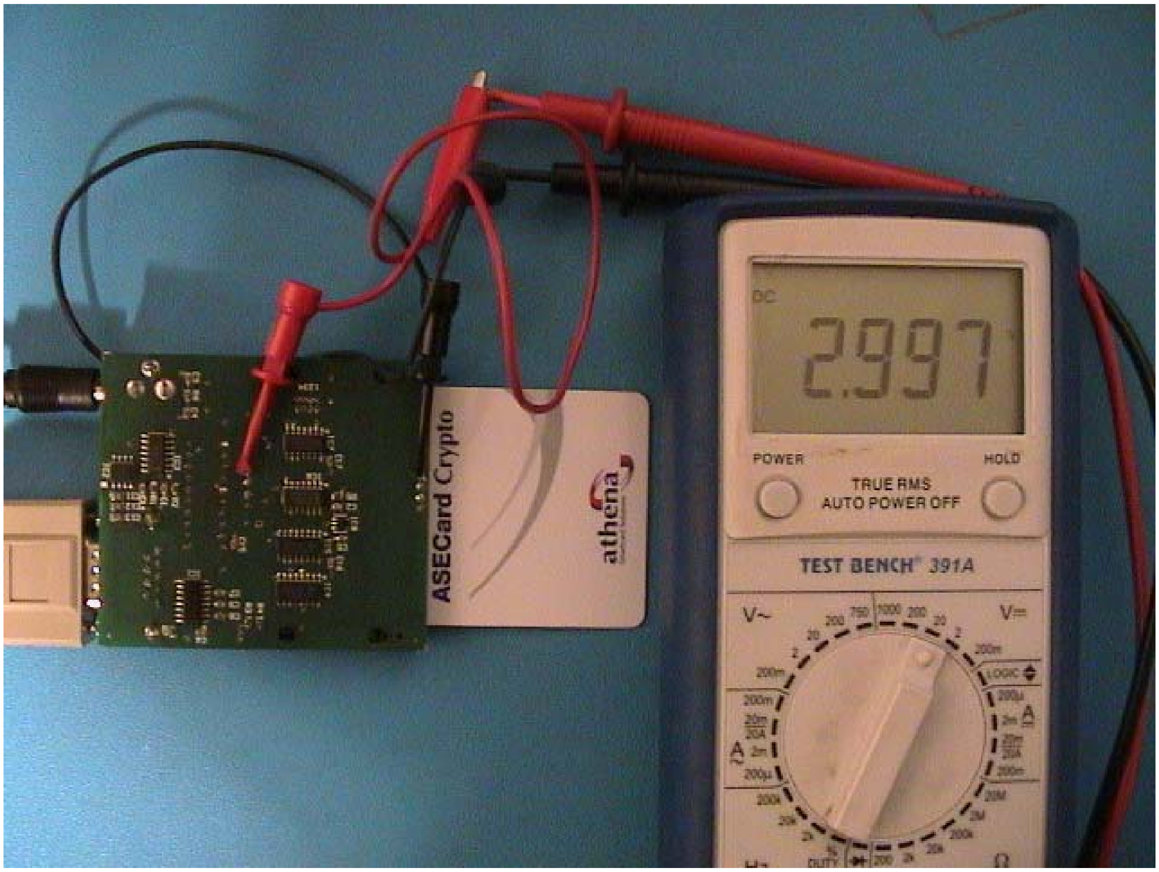

Figure 3: Bottom view of ASECard Crypto ISO7816 Class B smart card in Whiteviper unlooper running iso7816_vcc. The digital multimeter is displaying the DC voltage being supplied between the VCC and GND contacts of the smart card slot.