HT66F43x0 Smart Card Reader MCU Integrated ISO7816-3 Application Guidelines

Introduction
The Holtek 8-bit Smart Card Reader Flash MCUs, the HT66F43x0 device series, include an ISO7816-3 smart card reader interface. Since the electrical characteristics between the card reader terminal and the smart card (chip card) as well as the transmission protocol must be certified by the EMVCo unit, the MCU integrated ISO7816-3 interface plays an important role. In addition to the integrated ISO7816-3 interface which meets the EMVCo certification, the devices also include a fully integrated DC/DC converter to provide an input voltage for the internal LDO, which then can output voltages of 5V, 3V and 1.8V which are used to support three types of smart card voltage applications. This application note will mainly introduce the features of the Holtek MCU integrated ISO7816-3 and provide application considerations for the integrated DC/DC and LDO functions, to allow easier use of the devices.

Application Areas

USB Smart Card Readers
Among associated bank products the most common ones are USB smart card readers used by web ATMs, etc. Using these cardholders can implement bank transfers, payments and other internet bank transactions at home. Online shopping is also very popular in Europe and in the United States, however undesired internet transaction losses occur often due to unauthorised magnetic stripe cards from hackers and illegal groups. For added security, in recent years banks in various countries have provided smart cards (chip cards) to replace magnetic stripe cards. The HT66F43x0 devices all support online firmware updates, meet with EMVCo certification and with their single chip design greatly reduce BOM cost.

ID Verification Card Readers
In addition to bank transactions, ID verification applications such as health insurance cards, social security cards and staff identification cards, etc., also need a card reader to communicate with computer readers. For instance, for a USB keyboard which has an additional card reader interface, its ID verification can be determined by the system defined certification agreement.
Bluetooth Smart Card Readers

In the future USB smart card reader products will be combined with Bluetooth technology allowing this combination of features to support mobile phones, tablet computers and other mobile devices. Mobile device online bank APPs are quite popular however only using mobile device for transactions still have their security issues. But using a combination of smart cards and card readers offers a way to enhance the security for mobile device online APP transactions. For more details regarding Bluetooth smart card readers, refer to FIDO alliance’s website, https://fidoalliance.org/, where all related transmission protocols and certifications defined by the alliance are provided.

Operating Principles

ISO7816

The international standard ISO7816 specifies the Smart Card specifications, as described below.

- ISO7816-1
  Physical Characteristics. It defines the physical specifications including the smart card tolerable operating temperature, static tolerance or tolerable bending as well as weight, etc.

- ISO7816-2
  Dimensions and Location of the Contacts. It defines the chip pin locations and smart card size.

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>C1</td>
<td>Supply voltage (VCC)</td>
</tr>
<tr>
<td>C2</td>
<td>Reset (RST)</td>
</tr>
<tr>
<td>C3</td>
<td>Clock (CLK)</td>
</tr>
<tr>
<td>C4</td>
<td>Not used; need not be physically present</td>
</tr>
<tr>
<td>C5</td>
<td>Ground (GND)</td>
</tr>
<tr>
<td>C6</td>
<td>Reserved for Future Use (RFU)</td>
</tr>
<tr>
<td>C7</td>
<td>Input/output (I/O)</td>
</tr>
<tr>
<td>C8</td>
<td>Not used; need not be physically present</td>
</tr>
</tbody>
</table>

- ISO7816-3

Electrical Interface and Transmission Protocols. Defines electrical signals and transmission protocols.

The transmission protocol is implemented by the MCU integrated ISO7816 interface. Electrical signals such as driving current and signal rising and falling edges, etc., should meet the electrical characteristics specified by this file.

Holtek provide an ISO7816-3 sample program for transmission protocol implementation, greatly assisting users in their development efforts and therefore reducing the development time. Designers can contact our sales department for assistance.
In the Taipei FIME laboratory HOLTEK has passed the Smart Card Reader Terminal Contact Level 1 certification.

ISO7816-1-ISO7816-13 and ISO7816-15 together define various Smart Card specifications. Standards starting from ISO7816-4, which define the smart card transmission Level 2 specifications, including encrypted transmission, file data management, etc., can be referred to on the official website www.iso.org.

ISO7816-3 Interface

The Holtek Smart Card Reader MCU integrated ISO7816-3 interface is comprised of the modules shown below.

- ISO7816-3 Hardware Interface
  The card connector has 8 connection points which are used to connect with the smart card. The smart card is powered by card connector VCC (C1) and GND (C5), VCC should be connected to the MCU CRDVCC pin. CRST (C2) is the reset signal pin, CCLK (C3) is the clock signal pin, CIO (C7) is the data input/output pin, CC4 and CC8 are reserved and CDET is the external smart card detection input pin. CC6, used in reader terminal, is the smart card programming voltage pin, VPP. Information on the relevant register controls can be found in the Smart Card datasheet Interface chapter.

- ISO7816-3 Clock Source
  The CCLK pin provides the clock source for the smart card, which is determined by the CRDCKS[1:0] and SMF bits in the ISOC register. The clock source is first divided by a ratio determined by CRDCKS[1:0]. It can then be further divided by two or not determined by the SMF bit.

CRDCKS1-CRDCKS0: Smart card interface clock source f_{CRD} division ratio selection
- 00: f_{CRD} = f_h /2
- 01: f_{CRD} = f_h /3
- 10: f_{CRD} = f_h /1
- 11: f_{CRD} = f_h /4

SMF: Smart card interface clock frequency f_{CCLK} selection
- 0: f_{CCLK} = f_{CRD}
- 1: f_{CCLK} = f_{CRD} /2
ISO7816-3 Internal Time Counters

For data transfers, some counters must be firstly configured before the ISO7816-3 interface can begin to communicate with the external card. There are three ISO7816-3 dedicated time counters included in the Holtek smart card reader MCUs, which are named Elementary Time Unit, ETU, Guard Time Counter, GTC, and Waiting Time Counter, WTC.

The following figure illustrates a transmission frame for the ISO7816-3 interface, where $t_{ETU}$ indicates the time unit for a data bit. One frame consists of a Start bit, 8-bit data and a Parity bit. The elementary time unit $t_{ETU}$ is obtained from the following formula.

$$t_{ETU} = \frac{F}{D} + \frac{1}{F},$$

where:

- $F$: clock rate conversion integer
- $D$: baud rate adjustment integer
- $C$: clock rate of Smart Card

![Transmission Frame Diagram](image)

The clock source of the Guard Time Counter, GTC, comes from the ETU output clock named $f_{ETU}$. The character transmission rate of the UART interface is controlled by $t_{GTC}$ generated by the GTC. Note that the guard time between the last character received from the Smart Card and the next character transmitted by the Smart Card interface (MCU) should be managed by the application program.

The Waiting Time Counter, WTC, with its clock source coming from $f_{ETU}$, generates a maximum time duration denoted as $t_{WTC}$. The data transfer is categorised into two types. One is the Character Transfer which means each data transmission or reception is one character. The other is the Block Transfer which means each data transmission or reception is more than one character. The information related to the data transfer type is contained in the Answer-to-Reset packet. A data transmission schematic diagram is provided below.
ISO7816-3 Transmission

The data transfer between the ISO7816-3 smart card terminal and the smart card is classified into the EMVCo Level 1 transmission protocols. To pass the EMV Contact Level 1 certification, firmware for ISO7816-3 protocol debugging is necessary. Holtek has provided a firmware sample allowing users to rapidly develop their related products.

DC/DC Control and LDO Voltage Output

There are three smart card operating voltages specified by the EMVCo certification unit, 5V, 3V and 1.8V. The Holtek smart card readers include a DC/DC converter and an LDO, which should be properly controlled by the application program to provide a stable output voltage for the smart card interface and the external smart card. The relevant control registers are described below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC2DC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DCEN</td>
</tr>
<tr>
<td>CCR</td>
<td>RSTCRD</td>
<td>CDET</td>
<td>VC1</td>
<td>VC0</td>
<td>UMOD</td>
<td>WTEN</td>
<td>CREP</td>
<td>CONV</td>
</tr>
</tbody>
</table>

DC2DC: 8-bit, DC/DC converter control register
- **DCEN**: DC/DC converter enable control
  - 0: Disable
  - 1: Enable
- **VSEL**: DC/DC converter output voltage (VO) selection
  - 0: 3.8V –– for LDO 3V or 1.8V output
  - 1: 5.5V –– for LDO 5V output

CCR: 8-bit, Card Reader control register
- **VC[1:0]**: LDO output voltage (CRDVCC) selection
  - 00: 0V
  - 01: 1.8V
  - 10: 3V
  - 11: 5V

The VC[1:0] bit field is used to select the LDO output voltage. The LDO input voltage is supplied by the DC/DC converter output pin, VO, and its output voltage is output on the CRDVCC pin. When an external smart card is inserted, the CRDVCC pin voltage is firstly set to 1.8V to detect whether an Answer-to-Reset (ATR) packet is returned. If not, then it will be switched to the next voltage level and so on, until an ATR package is received. Therefore the smart card reader MCU can support three card voltages and protect the smart card from being damaged due to incorrect operating voltages.

A DC/DC converter and LDO application circuit for the user’s reference is provided below. The inductor is a coil type inductor with a resistance as small as possible, a recommended value is to be less than 2Ω. The filter capacitors for the VO and CRDVCC pins can be changed according to applications aiming at passing the EMVCo certification. If the user products do not require the boost circuit, the AVDD and SELF pins can be
short-circuited to the VO pin, the DCEN bit should be cleared to zero and the VO pin should be connected to the power pin VDD so that the internal LDO can operate normally to provide the power supply to the smart card.

The DC/DC converter and LDO application circuit is shown below.

![Application Circuit Diagram](attachment:CardReader.SchDoc)

**Integrated DC/DC and LDO Features**

- **Operating Voltage**
  The operating voltage of the integrated DC/DC converter is in the range of 2.8V~5.5V. If the card reader products are powered by two dry cells, it is recommended to use the LVD function to detect the 2.7V low voltage and then stop card related operations. The VSEL bit can be used to select the required DC/DC converter output voltage level for the corresponding LDO voltage requirement. The relevant electrical characteristics can be referred in the Data Sheet DC/DC Converter and LDO Electrical Characteristics table.

- **Schematic**
  The HT66F43x0 smart card reader application note circuit is illustrated below. Refer to the attachment CardReader.SchDoc for the completed application circuit.
**Schematic Considerations**

The HT-SCR100 Demo Board has provided a smart card reader schematic circuit sample to assist users with rapid product development. When designing the application circuit, it is important to ensure that the filter capacitors for the DC/DC converter and LDO are all located as close to the MCU as possible. The card connector and RC filter circuits are reserved for signal quality adjustment during certification testing. If an RTC circuit is used by externally connecting a 32768Hz crystal, the crystal and any associated resistors and capacitors along with interconnecting lines should be located as close to the MCU as possible. Refer to the Data Sheet for the recommended values of the external connected resistors and capacitors. The overall application circuit is composed of the following sections.

- **USB Power and Filter Circuit (Figure A)**

![Figure A. USB Power and Filter Circuit](image)
◆ DC/DC & LDO, RTC, Buzzer and LED Circuits (Figure B)

![Figure B. DC/DC & LDO, RTC, Buzzer and LED Circuits](image)

◆ Card Connector and RC Filter Circuits reserved for certification (Figure C)

![Figure C. Card Connector and RC Filter Circuits](image)

◆ PCB Layout Considerations

On the HT-SCR100 Demo Board, the filter capacitors should be located as close to the MCU as possible to reduce power line interference. The VSS copper area is divided into three sections.

◆ USB power - if a USB circuit is designed

◆ DC/DC power - analog booster circuit

◆ CRDVCC power - chip power circuit
To ensure that the Demo Board can successfully pass the EMI/VCo Smart Card Reader Level 1 certification, some locations are reserved for smart card circuit filter resistors and capacitors which will be used for signal quality debug during certification testing.

Conclusion

This application note has introduced the smart card reader ISO7816-3 interface transmission protocols and summarised some considerations regarding the power circuits. If required, designers can contact our sales offices for authorised ISO7816-3 sample programs.

Reference File

Reference file: HT66F43x0 Data Sheet.

For more information refer to the Holtek’s official website http://www.holtek.com.tw.

Versions and Modification Information

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