

LTC1755 Smart Card Interface Provides Inductorless Boost and Signal-Level Translators

by Steven Martin

Introduction

Already common in Europe and some of the Far East, smart cards may soon replace magnetic stripe cards in the U.S. The LTC1755 provides a simple and complete solution to smart card interfacing. Requiring only two bypass capacitors and one charge pump capacitor, the LTC1755 interfaces seamlessly between a smart card socket and a host microcontroller. It is designed to comply with all of the available electrical standards for smart card interfacing. Figure 1 shows the LTC1755 in a typical smart card application.

Figure 2 shows the block diagram of the LTC1755. An internal power management unit delivers a selectable 3V or 5V regulated output voltage to the smart card. Two unidirectional and three bidirectional communication channels provide the signal translation necessary to interface from a microcontroller at one supply voltage to a smart card at another supply voltage. A smart card detection channel observes the state of a mechanical switch and delivers the information to the microcontroller after an appropriate debounce period. Finally, the

LTC1755 provides all fault detection necessary to comply with both the EMV and ISO-7816-3 smart card standards. These include short-circuit detection, smart card removal during a transaction and undervoltage and overtemperature faults. In the event of a fault condition, the smart card is properly deactivated and an alarm output notifies the microcontroller of the fault.

Power Management Unit

Unlike solutions that require an external inductor and current sense resistor to generate power to the card, the power management section of the LTC1755 requires only a small flying capacitor to provide step-up capability. Sense circuitry determines how much input voltage is available and decides whether to step the input voltage up or down to provide the required output

voltage to the smart card. For example, if the input supply voltage is 3.3V and the required smart card

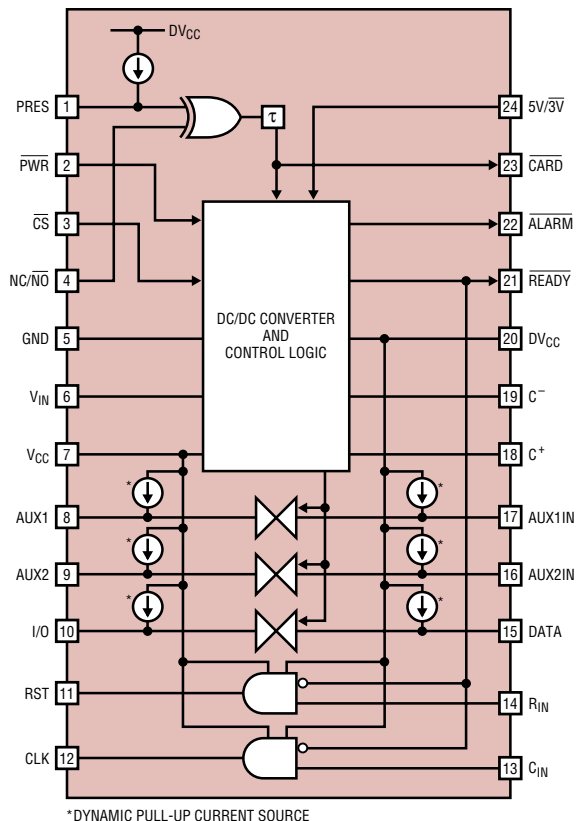


Figure 2. LTC1755 block diagram

voltage is 5V, the LTC1755 will operate as a charge pump to deliver the higher voltage; if the input supply voltage is 5V and the required smart card voltage is 3V, it will automatically step down to provide the correct output voltage.

The entire LTC1755, including the power management circuitry, is designed to consume low power under light or no load conditions. This can result in considerable power savings for battery-powered applications. Furthermore, the shutdown current is only several microamperes.

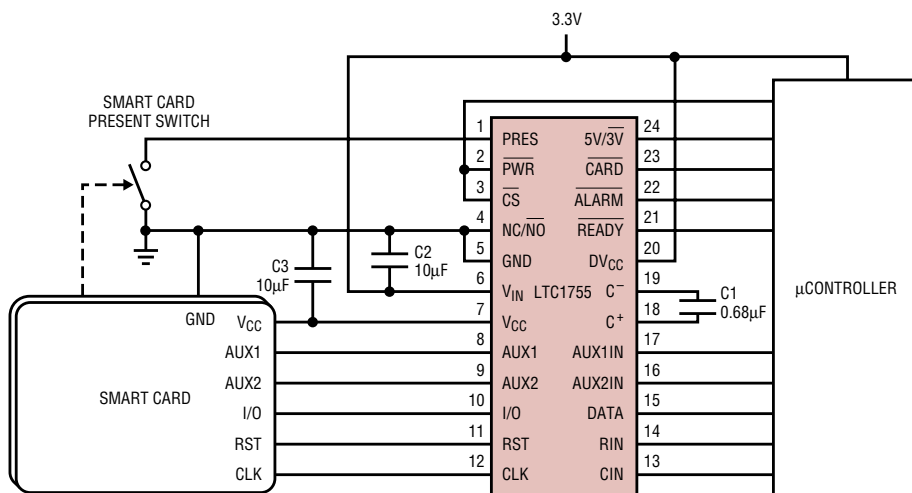


Figure 1. LTC1755 typical application

To prevent high inrush current during turn-on, an automatic soft-start feature increases the supply voltage of the smart card at a fixed rate. This is particularly important when the LTC1755 is in step-up mode because the input current will be twice the output current. With a 10 μ F output capacitor, the rise time of approximately 2ms limits the input current to 50mA, thus preventing start-up problems. The **READY** pin tells the microcontroller when the output voltage has reached its final value. This signal also enables the communication channels, thereby ensuring proper compliance with smart card standards. Figure 3 shows the card supply voltage ramp as well as the **READY** pin indicating that the output has reached its final state.

During smart card deactivation, either by direct user control or by automatic fault deactivation, the LTC1755 discharges the smart card supply pin in under 250 μ s. Rapid discharge is important to ensure that the card's supply is completely removed in the event of smart card removal during a transaction. This requirement is specified in various smart card standards.

Bidirectional Communication Channels

There are three bidirectional channels for communicating with the smart card. These channels, which are open-drain I²C™ style, provide level

translation, direction arbitration and short-circuit protection. Unlike analog approaches, the LTC1755 uses control logic with active pull-up and pull-down devices on both sides of the channel. This allows the required source and sink currents to be achieved independent of the input voltage on the transmitting side of the channel. The direction-control logic arbitrates which side of the channel is the *talker* and which side is the *listener*. Upon receipt of a low on one side of the channel, that side becomes the talker and the other side becomes the listener. Transmission in the opposite direction is instantly blocked to prevent the channel from latching. Once the talker side of the channel is relinquished, both sides return high and either side is a candidate to become the next talker.

To meet the stringent rise-time requirements imposed by ISO-7816-3 while keeping power dissipation and V_{OL} to a minimum, an accelerator circuit (see Figure 4) is built into each pull-up current source on the bidirectional channels. Normally, a small current, I_{START} , pulls each bidirectional pin to its respective power supply rail. An open-drain transistor can easily overcome I_{START} whenever a low is asserted. When the low is relinquished, I_{START} slowly begins to charge the pin toward its rail again. An internal edge-rate-detection comparator notices that the node is moving upward and fires a large pull-up cur-

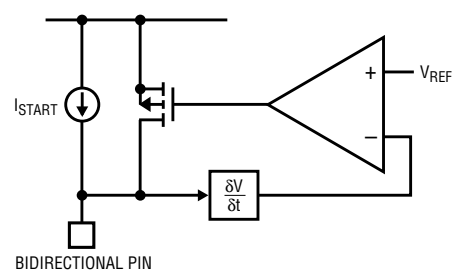


Figure 4. Dynamic pull-up current source

rent source to assist. Once the larger current source begins to enhance the edge rate of the node, the decision to enhance is reinforced, thereby effecting a dynamic form of hysteresis. After the node has reached the power supply rail, the comparator resets and only I_{START} is available again. Figure 5 shows the waveform of a bidirectional pin. The 10% to 90% rise time is on the order of 150ns.

Unidirectional Communication Channels

There are two unidirectional channels on the LTC1755 that provide the level-shifted clock and reset signals used by the smart card for synchronization. The clock channel is designed specifically for high speed and can faithfully transmit a 5MHz signal. Both of these channels are disabled and provide a valid low before the smart card supply voltage has reached its final value. Once the card supply voltage is valid, these channels will simply transmit the signals present

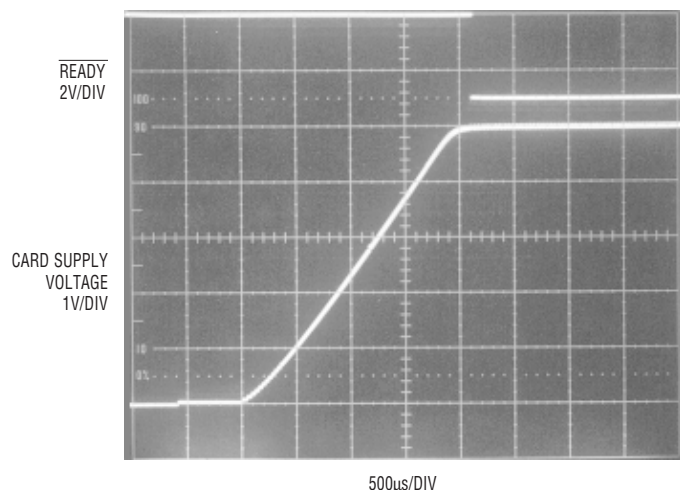


Figure 3. Smart card supply voltage and **READY** upon activation

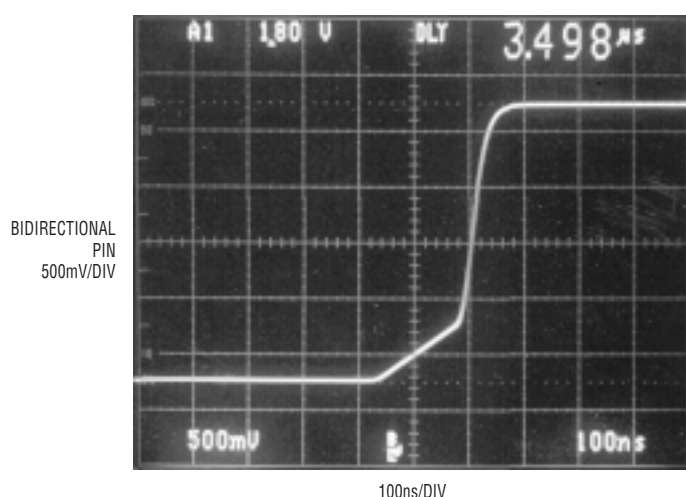


Figure 5. Bidirectional pin with dynamic pull-up

at their respective inputs. To comply with smart card standards, the RST pin is always brought low before the CLK pin upon deactivation.

Smart Card Detection Channel

The LTC1755 incorporates the only card detection solution that does not require additional de-bounce circuitry or software. This channel detects the presence of a smart card by forcing a small current and monitoring the voltage on a mechanical detection switch. Once a smart card is detected, the channel starts the debounce timer. The presence of a card is reported to the microcontroller only if the card has been present for a minimum of 40ms. Existing solutions provide either no debounce capability or minimal (only tens of microseconds) debounce time. These solutions require additional software or hardware to mask out the transients associated with the physical insertion of the smart card. Also, unlike other solutions, the switch-sense current is generated by the LTC1755 so no external components are required. Once a valid card indication occurs, the channel alerts the microcontroller by asserting the CARD pin.

For maximum flexibility the smart card detection channel can be programmed to respond to either a normally open or normally closed switch. A built-in XOR gate is used as a controlled inverter to provide this function.


Fault Detection and Avoidance

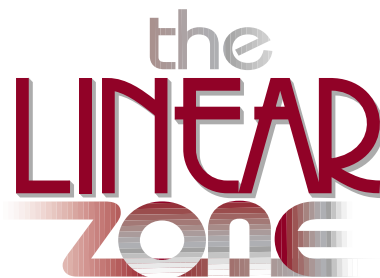
Specifications relating to faults on the smart card pins are very stringent. For example, ISO7816-3 (section 1.4.8) specifies that the smart card socket must be capable of surviving a "metal plate" connection between any or all contacts without damage. To accommodate these fault conditions, the LTC1755 uses voltage sensing on the low impedance pins to detect if they are being forced to an inappropriate level. For example, the voltage on the smart card supply pin, V_{CC} , is compared with an internal reference to determine if a short circuit exists. If a fault persists for a prescribed period, the LTC1755 automatically deactivates the smart card and asserts the $\overline{\text{ALARM}}$ output. The small timeout period prevents false errors from plaguing the microcontroller. The clock and reset channels respond to faults in a similar way. The digital levels on the outputs of these channels (CLK and RST) are compared to those being presented at their inputs. If these signals differ for several microseconds, a fault is declared and the smart card is deactivated. Again, the $\overline{\text{ALARM}}$ output alerts the microcontroller that an electrical fault exists. In both cases, since the smart card becomes deactivated, there is no power available to deliver excessive current for a prolonged period.

The three bidirectional pins on the smart card side of the channel are protected against short circuits to the

smart card supply voltage by means of a constant-current pull-down output. Rather than a simple pull-down transistor to transmit a low to the smart card, these channels use a current source implementation. The 3.5mA current source provides enough current to meet the edge rate and V_{OL} requirements while limiting the current available during a fault. The available smart card standards specify that no more than 5mA flow during faults on these pins. Of course, short circuits to ground on these channels are indistinguishable from a normal signal and must be detected by the data-error checking routines.

Conclusion

The LTC1755, designed specifically for smart card applications, provides all of the necessary level shifting and power circuitry to interface with a smart card socket. To further reduce board level complexity, it includes a smart card detection channel with built-in debounce circuitry. Since the LTC1755 provides all of the necessary smart card interface functions, only bypass capacitors and one charge pump capacitor are required for operation. Under most circumstances the operation of the LTC1755 is simple and provides a nearly transparent path to the smart card. However, when an electrical error condition occurs the LTC1755 responds quickly by powering down the smart card and alerting the microcontroller. 



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