Improving Consumers’ Contactless Payment Experience

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Executive Summary

Contactless cards are a key technology for improving the consumer experience for retail transactions. Both computational speed and RF sensitivity are factored into the consumer’s perceived transaction time. So a balance between speed and energy efficiency (a.k.a. sensitivity) is required in the chip design. The sensitivity of the contactless card is a more important metric than the computational speed, but the implementation of both translates into a better, overall user experience. Implementing a highly sensitive solution equates to a larger read zone and provides more time for the contactless card and the reader to complete a transaction while the card is in motion. The larger read zone means there is less hunting for the sweet spot on the reader. TI has a series of contactless payment products designed specifically to offer high sensitivity and enable custom, small form factor payment devices beyond cards. Ultimately, this results in putting an evolutionary form of payment in the consumers’ hands.
Improving Contactless Payment

Contactless: Evolutionary Form of Payment

Contactless technology is changing the way consumers pay. Just as swiping a magnetic card was an improvement in speed and convenience over the antiquated carbon copy paper receipts, the speed and convenience of a “wave and go” model offers an evolutionary payment improvement that delivers a better experience. Additionally, there is more security and consumer confidence associated with contactless payment methods. While contactless cards hold the same transaction data as a magnetic strip, there is a key difference. Contactless cards are layered with a more sophisticated authentication and encryption scheme. This, in turn, provides the issuing banks confidence in the transaction legitimacy.

To handle this extra layer of security and data integrity, contactless cards must have:
- Computational capability for encryption
- Secured memory with data access control
- RF receiver/transmitter capability to communicate with the reader

Designing a high performance contactless card with all of these capabilities can involve tradeoffs in chip processing speed and efficiency. As with all chip-based devices, just like any computer processor, the higher the chip computational speed, the higher the power needed to drive the circuitry. In a contactless payment transaction, improving the power efficiency of the chip can improve the communication time between an RF reader and the card; thus putting time on the consumers’ side for completing the payment transaction. To preserve the consumers “wave and go” experience as opposed to a “hold and wait” or “hunt and curse” experience, perceived transaction time is an important factor and should be kept short. Improving the power efficiency of the chip has other benefits when it comes to transaction time and is detailed in a later section of this paper.
What is Transaction Time?

From a consumer’s point of view the transaction time starts when the card is pulled from the wallet and ends when he or she walks away from the cash register. Figure 1 below shows the major elements involved in processing a contactless transaction from beginning to end. Each link can be likened to a series of conversations: card and reader, reader and merchant host, host and bank server, etc. Each “conversation” is important to minimize, but a typical consumer will only notice the sum total of the conversation times.

![Transaction System Diagram](image)

**Figure 1: Transaction System**

An integrated circuit (IC) or chip designer’s point of view is usually limited to the time it takes for the contactless card to receive, process, and respond to a reader’s command set. The time it takes to wave or tap the card and hear the reader’s “beep” (positive indication the card was read) should be instantaneous. The “wave to beep” time is influenced by the quality of the RF communication link and the ability of a contactless card to process the series of commands from the reader.
Figure 2 shows the elements of a contactless transaction: 1) reader and card communication, and 2) card authentication over the payment network. The reader/card communication consumes a much smaller proportion of the overall transaction time. In fact, the only noticeable time should be the online authorization process.

Figure 2: Transaction Elements

Figure 3 shows a methodology that can be used to measure the chip and reader transaction speed. Speed can be measured directly with the reader or by using a tool, such as a real time spectrum analyzer, that can monitor and measure the RF communication stream.

TI’s MasterCard PayPass™ chip has a transaction time of 130ms, or approx 1/8 of a second. This transaction speed is a simple measurement of the time it takes the reader to send commands and for the internal chip to process those commands. 130ms is below the threshold most humans would perceive as a “tap” rather than a “hold” and it is clearly not a bottleneck in the user’s overall contactless payment experience.
RF Chip Sensitivity and Transaction Reliability

When it comes time to make a purchase with their contactless cards, consumers expect to present their card once and be on their way. Having to repeatedly wave the card around to find just the right spot to get a “beep” is an annoying inconvenience equivalent to swiping a magnetic stripe multiple times. For contactless cards to gain more consumer acceptance and to be perceived as superior to conventional cards, consumers should not have to re-orient their cards.

To achieve greater transaction ease and reliability from contactless payment devices, it is important to understand the how RF energy and power efficiency affects the transaction. The contactless communication is split into two parts:

1. Reader to Card: The reader puts out an electro-magnetic field to communicate with and to power the contactless card. The energy level of the field drops over distance. The size and shape of the field is a function of the reader’s power output (more power = larger field) and the size/shape of the reader’s antenna (along with and a few other parameters)

2. Card to Reader: The contactless card uses the energy it harvests from the electro-magnetic field to power itself and transmit back its part of the communication to the reader. The chip inside the card has minimum power requirements, and if the field is not able to provide enough energy, the contactless card will not turn on. If the field is weak, the contactless card may attempt to communicate with the reader, but it may not be able to transmit a signal strong enough for the reader to “hear”.

Sensitivity is more specifically, the minimum amount of energy needed to power the chip and allow it to transmit an understandable signal. Highly sensitive chips require less power to operate. Sensitivity can be expressed in electrical units such as A/m or dBµA/m, but read range is often used as a proxy and can be easily understood and compared by users.

Figure 4 shows a simplified example of how to correlate the sensitivity of a contactless card to read range. The graph illustrates a reader field strength distribution vs. distance of a card from a typical reader represented by the blue line. The figure also illustrates the minimum activation field strength for both a low sensitivity (or high power requirement) contactless card of 123.5 dBµA/m (representing the ISO defined minimum operating field strength), and a high sensitivity (low power requirement) contactless card of 115dBµA/m. It is clear
that a high sensitivity contactless card has an approximate 50% greater reader range than the card containing a low sensitivity chip.

The overall sensitivity of a contactless card is a function of the internal chip’s sensitivity and its various antenna parameters such as size and winding geometry. Low sensitivity chips require a larger antenna to achieve acceptable read range. In Figure 5 we see an illustration of readability for different contactless cards in a given reader field. The high sensitivity contactless card has a much greater volume of space in which it can turn on and communicate. The consumer will therefore, not have to hunt for a small volume of space comprising the read zone when he or she presents the contactless card to the reader.

Figure 4: Sensitivity vs. Read Range
To be clear, it is important to address the element of information security for payment cards with robust read ranges as it relates to sensitivity. Some might fear the possibility that a well-equipped thief could steal a consumer’s payment information if the card has “too much” read range. This actually presents yet another advantage to contactless payment because with high sensitivity you are given the option of using a smaller antenna to achieve the optimal read range for reliability and security.

The Sweet Spot for Cards and Beyond

In contactless device design, extreme chip sensitivity is a key factor in a true “wave and go” consumer experience. Acute chip sensitivity equates to a larger read zone and more time for the contactless card and reader to complete a transaction while the card is in motion. An optimal read zone also means consumers don’t have to search for the sweet spot on the reader.

A highly sensitive chip makes it possible for the small form factor contactless devices to maintain at least moderate, overall sensitivity with the requisite smaller antenna, while also ensuring the optimum consumer experience at the checkout. Issuers can offer a broad range of alternative payment devices to their customers, such as key fobs, which provide a greater range of convenience and personalization options. Consumers can indulge their individual tastes and interests with personalized form factors, while enjoying the benefits of a faster, more convenient transaction experience. It is important to understand the relevance of having acute sensitivity. Its relevance is even more important when discussing form factors because low sensitivity chips simply cannot function with smaller form factors, especially if they are barely functioning with a full card-size antenna.

TI’s philosophy is to design a “just right” chip that ensures consumers’ have a positive experience with contactless payment. Our RF expertise, capabilities
related to high-chip sensitivity and power efficiency has helped us be the first company to develop a fully-certified MasterCard PayPass contactless payment product without waiver restrictions. High RF sensitivity creates flexibility in payment device design and provides the freedom for customers to innovate around our technology, resulting in better products and more choices for the end user. In fact, TI offers customers several options for integrating its highly-sensitive, contactless chip into their payment devices providing standard ISO card pre-laminates, fob sized pre-laminates, and even individual modules for customers who want to design proprietary antennas. When no longer constrained to a standard card size antenna to achieve readability, a card issuer has endless opportunities to differentiate its contactless products or target specific demographic groups with non-card form factors.

About the Authors

Chris Cook is an application specialist for Texas Instruments, Inc. In this role, he works with contactless payment customers to provide application advice, testing, and technical assistance. With more than 12 years of experience in electronics, Chris leverages his expertise in designing and managing electronics packaging solutions in support of TI’s contactless payment business.

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