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Next-generation contactless payment terminals: how to improve RF performance while saving space and BoM cost

By Ying Dong
Product Marketing Manager, Panthronics AG

www.panthronics.com

Near Field Communication (NFC) technology provides a secure, low-power means of data exchange between two devices in proximity to one another. Consumers have enthusiastically adopted the technology for applications such as ticketing and contactless payment because of its convenience.

This broad acceptance depends on the technology being easy to use – it has to just work, every time. And for manufacturers of payment terminals which are equipped with an NFC reader for contactless payments, this is becoming harder to achieve. Today's terminals have to work perfectly not only, as before, with payment cards, the design of which is optimized for NFC operation: they also have to achieve instant, flawless RF coupling with devices such as mobile phones, smart watches and other types of wearable product in which the NFC physical interface is constrained, for instance by the small size of the antenna or by a metallic enclosure.

To reflect this, the global standard set of specifications for the operation of contactless terminals – the EMVCo standard sponsored by leading payment card and banking companies – has introduced a new version 3.0 of its specifications, imposing much tougher requirements for the RF performance of payment terminals in parameters such as power control and waveshape distortion.

At the same time, a new generation of contactless payment terminals is emerging which features a large touchscreen display and sophisticated applications, mirroring the look and feel of a smartphone (see Figure 1). The goal of the terminal manufacturers is to make the payment process as quick, easy and convenient for the shopper as possible. New terminal designs are dominated by a large touchscreen display on which the text and numbers are easier to read. Some terminals dispense with a keypad, providing virtual buttons on the touchscreen instead.

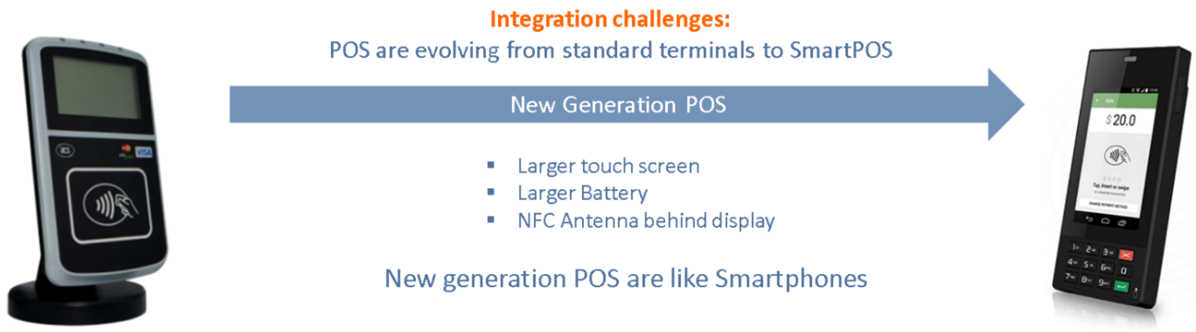

Fig. 1: the evolution of payment terminal design. (Image credit: Panthronics)

This new style of terminal, in which the front is occupied by a large display and no keypad, has no space for a dedicated landing area, so the NFC antenna has to be relocated behind the display. This introduces a critical level of interference between the NFC antenna and the display: the display acts as a shield between the antenna and an external device, and also generates noise which influences NFC signals. The interference is bidirectional: an excessively strong NFC field can cause flicker on the display.

In the face of this combination of higher RF performance requirements and a compromised RF operating environment, many terminal manufacturers are re-evaluating their choice of RF controller IC. The NFC controller market has long been dominated by a handful of semiconductor manufacturers which have supplied products adequate for the moderate demands placed on them by old-style terminals intended for use with contactless payment cards.

The limited RF capabilities of these NFC controllers, however, have been exposed by the new trends in terminal design, and by the challenges of compliance with the EMVCo 3.0 standard. These conventional NFC controllers are hampered not by some minor flaw which can be rectified through a simple hardware modification or software fix: the problem is hard-wired into the silicon, in an architecture which generates a square-wave RF output signal.

To solve this problem, Panthronics has developed a completely new NFC controller architecture. This new Panthronics controller design has such good RF performance that it can achieve EMVCo 3.0 compliance with an antenna as much as four times smaller as previous controllers require. It also uses far fewer external components, resulting in a lower bill-of-materials and assembly cost and simpler integration into the end product design.

Tougher set of interoperability tests

The drive to achieve dramatically improved RF performance comes in response to the introduction of the EMVCo 3.0 specifications, which came into force on 1 January 2020. Under the previous v2.6 EMVCo standard, terminals were subject to around 600 tests and had to demonstrate interoperability with just one type of reference device – in the terminology of the NFC community, a PICC (proximity integrated circuit card).

Under EMVCo 3.0, the regime has been extended to 2,000 tests, and it verifies interoperability now with three PICC reference boards. The intent of the new specifications is to ensure that terminals operate flawlessly with device types, such as smart watches, which have a small antenna mounted behind a display or other noisy component.

Terminal manufacturers which have evaluated the performance of conventional NFC controller ICs against this new set of benchmarks have discovered their limitations. All these conventional controllers share a similar silicon architecture which generates a square-wave output signal (see Figure 2).

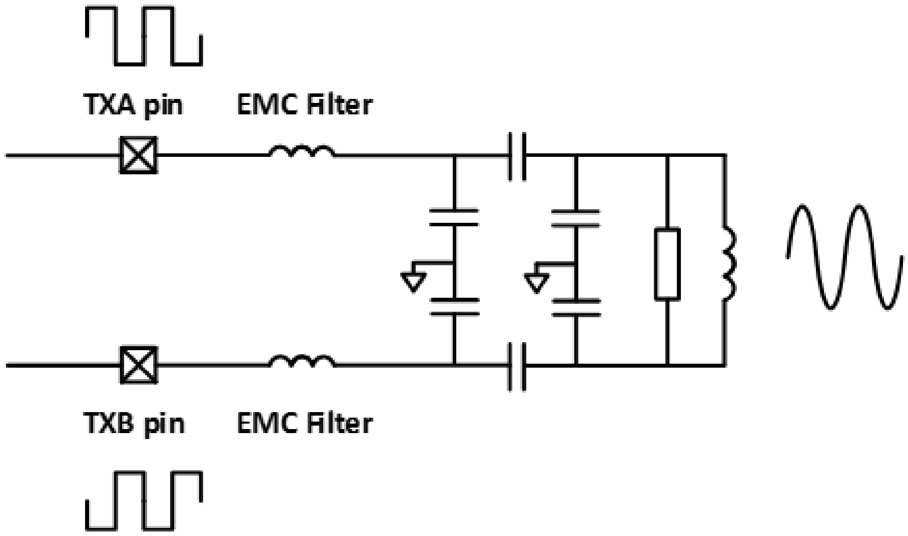

Fig. 2: the conventional architecture of NFC controllers used in today's contactless payment terminals. (Image credit: Panthronics)

Controller manufacturers originally adopted this square-wave architecture because it is easy to implement in silicon. But this square wave output has to be shaped as a sine wave for signal transmission via the antenna, and this calls for an EMC filter made up of multiple external components. In payment terminals' RF circuits, this architecture suffers from drawbacks including:

- High power losses and low output (transmit) power, which limit the operating volume that the device can achieve
- Low sensitivity in the receiver circuit, where input signals are attenuated by the multiple external components. This also limits operating volume.
- These two factors force the adoption of undesirable design strategies, such as the use of a large, high-impedance antenna and of an expensive, low-noise display.
- At best, this architecture offers coarse control of power output, which can lead to saturation of devices close to the terminal unless the OEM adds cumbersome and costly power-control circuitry. It also makes it difficult to generate a high enough power output to achieve reliable connectivity at a long distance from the antenna.
- Imprecise wave shaping in the output signal, hampering and slowing efforts to pass the full set of interoperability tests specified in the EMVCo 3.0 specifications
- The use of an EMC filter also introduces an additional resonant circuit, which makes the system much more prone to detuning.

All-new architecture features sine-wave output

The root of all these problems is the square-wave output which conventional NFC controllers generate. The alternative – generating a sine wave at the output pins – solves all of them. Now Panthronics has made patented innovations which have enabled it to implement a sine-wave architecture in silicon (see Figure 3).

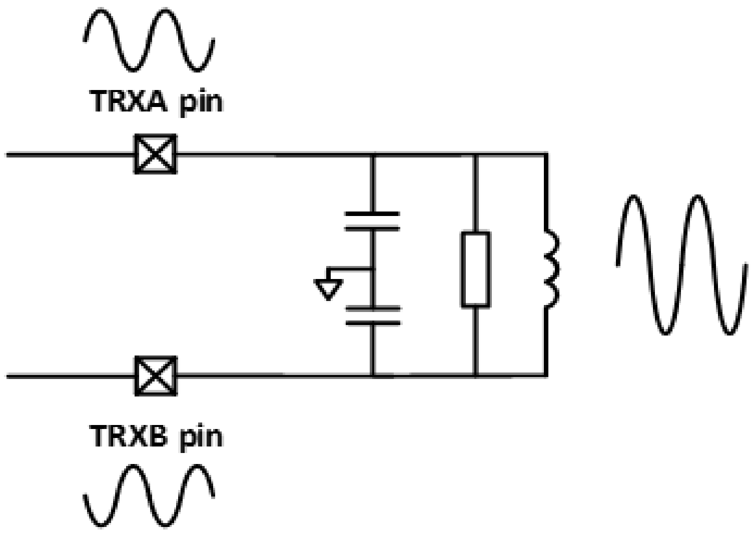

Fig. 3: the Panthronics sine-wave architecture implemented in its PTX100R NFC controller requires no EMC filter and few antenna-matching components. (Image credit: Panthronics)

The key advantages of this architecture are the mirror image of the drawbacks of the conventional NFC controllers:

- Losses are greatly reduced because the EMC filter and most matching components are eliminated. This means that the PTX100R can offer a high output power, which enables a terminal to achieve EMVCo 3.0 compliance with a small, low-impedance antenna.
- Because the controller produces a sine-wave output, it can achieve much finer wave shaping, greatly reducing over-shoots and under-shoots. This results in much better interoperability and effective coupling even through a smaller antenna.
- Very fine output power regulation to prevent saturation even when the terminal is very close to the PICC.
- In the receiver circuit, the sine-wave architecture also provides a direct connection between the antenna and the controller IC, resulting in higher sensitivity of around -80dB – two orders of magnitude greater than that of conventional NFC controllers (see Figure 4). This enables the use of a noisy, low-cost display without compromising connectivity with external devices.

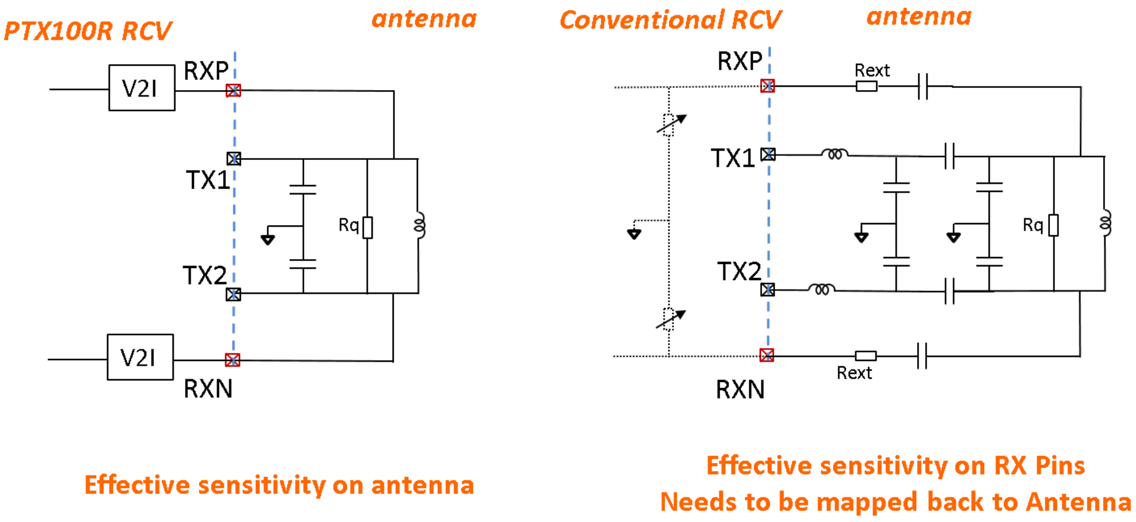

Fig. 4: PTX100R achieves higher sensitivity because of its direct antenna connection. (Image credit: Panthronics)

In combination, these factors provide the design freedom, straightforward standards compliance and high RF performance which the new generation of smart payment terminals requires. A reference design board developed by Panthronics achieves EMVCo 3.0 compliance at Level 1 (for the physical interface) with an antenna measuring just 900mm^2, some four to five times smaller than that required when using a conventional controller IC.

In addition, the elimination of the EMC filter and other external components typically produces a board area saving of more than 40mm^2, reducing the cost and complexity of a terminal design's board. The PTX100R thus gives terminal manufacturers new flexibility to rethink their designs, for instance enabling the implementation of terminals in wearable form factors which are smaller and lighter than ever.

The improved RF performance which results from higher output power and higher sensitivity has a direct impact on the user experience and on the potential for new payments applications. Panthronics reference designs achieve RF performance substantially above the levels specified by EMVCo 3.0, and this results in ultra-reliable interoperability with all types of NFC device.

It also creates the potential for new applications for contactless payments, such as peer-to-peer payment, by which a smartphone user can make an instant money transfer to another smartphone or smart watch via NFC.

The PTX100R is intended for use in contactless payments terminals, and it includes a novel software implementation in which all low-level NFC functionality is implemented in the controller. This relieves the burden on the host application processor and quarantines all timing-critical functions inside the NFC controller. This substantially reduces the effort involved in the implementation of the NFC Forum protocol specifications.

For the contactless payment sub-system, the PTX100R includes a dedicated EMVCo hardware accelerator. This provides for a very efficient implementation of EMVCo signalling, as shown in Figure 5.

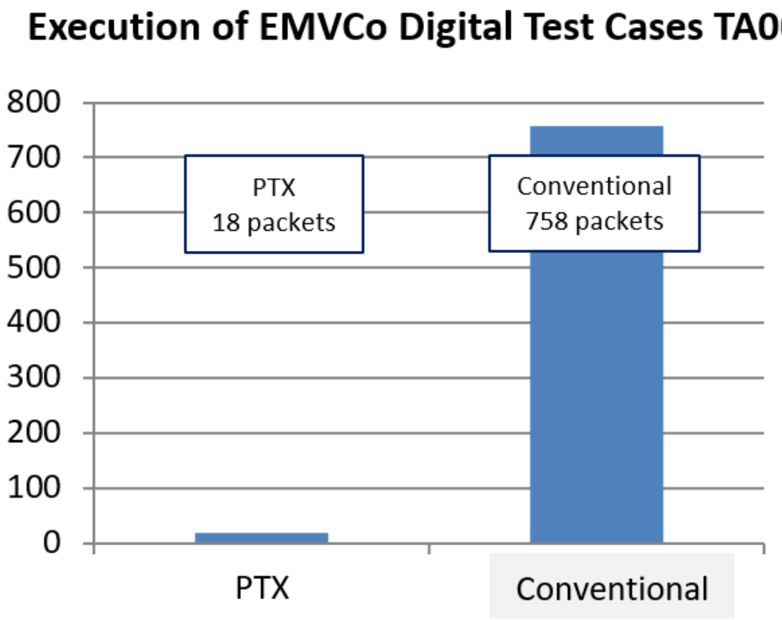

Fig. 5: comparison of the efficiency of data packet transfers made by the PTX100R (left) and by a conventional NFC controller (right) in a typical EMVCo operation. (Image credit: Panthronics)

As this article shows, conventional NFC controllers have found themselves trapped by a silicon architecture which was adequate for the first wave of contactless payment applications, but which creates difficulties for terminal manufacturers which wish to modernize their product designs while achieving compliance with the new EMVCo 3.0 standard's specifications.

By introducing an all-new sine-wave architecture in the PTX100R controller IC, Panthronics is providing an innovative solution which offers higher RF performance. This supports the use of a smaller antenna in challenging operating environments while providing for easy integration into the system design and reducing BoM cost and size.

The PTX100R not only enables the next generation of contactless payment terminals with a large display, but also future smartphones which offer point-of-sale features.

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Press contact:
Tracy Annandale, TKO Marketing Consultants, tracy@tko.co.uk