Designing a multi-standard 13.56 MHz RFID base station device

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There are a number of different standards and protocols at this frequency, making a universal multi-standard reader/writer unit a highly desirable product to system integrators working at this frequency.

This article outlines the basic design concepts for the development of such a multi-standard unit, based around Philips Semiconductors' CLRC632, a dedicated multi-standard 13.56 MHz base station IC, showing the simplicity of design required.

Why 13.56 MHz?

13.56 MHz is popular because this frequency is less affected by the presence of water, the human body, metal, and extraneous field characteristics than are higher frequencies such as 900 MHz and 2.45 GHz. RFID systems at 13.56 MHz operate reliably in the presence of such factors up to a range of 1.5 m. The antenna requirement at 13.56 MHz is smaller than lower frequencies such as 125 kHz, giving tag designers more flexibility without drastically reducing read/write range. This frequency is low enough to operate on a magnetic coupling principle, as opposed to pure RF, whilst being high enough to require small antennae.

The magnetic coupling concept is shown in Figs. 1 and 2. Fig. 1 shows that the tag is powered by the magnetic field set up by the base station and data is transferred between the tag and base station while the tag remains in the base station's field.

Fig. 2 shows how the tag is powered, addressed and read from, by the base station, according to the protocol set out in ISO14443A.

Magnetic coupling

When a tag is brought into the base station's field, the coupling effect results in the detuning of the base station's antenna. This in turn increases the current through the antenna. Thus, the base station detects the presence of the tag entering its field by noticing the increase in current consumption caused by the detuning of its antenna. According to the protocols applied in software, the base station interrogates the tag and reads its unique identifier, or serial number. The transaction occurs as the base station and tag exchange data.

Large installed base

There is a very large installed base of RFID systems operating at 13.56 MHz. There are more than 1 billion RFID tags and about 500 million contactless smartcards in daily use around the world. These can be found in diverse applications including retail, warehousing, parcel delivery, libraries, animal ID, gaming, sports, public transport, access control, etc.

Why multi-standard?

The above pictorial example complies with ISO14443A. However, there are other protocols too, which share the 13.56 MHz band space. Some of these comply with ISO specifications, such as ISO14443B and ISO15693; while others are proprietary standards.

It is thus desirable to offer the market a fully compatible base station unit capable of addressing as many of the different protocols as possible, thereby making the base station independent of the tags presented to it.

Manufacturers producing such units can produce a single basic product in high volumes, tailoring the final product to their customer's requirements in software shortly before delivery.

Design concept

The design concept outlined below is centred around the CLRC632 multiple protocol contactless reader IC. Although it carries the name "reader IC" it is in fact a RFID proximity coupling device (PCD), a bidirectional interface, capable of reading data from, and writing data to, the tag or transponder IC. In the concept that follows, the CLRC632 will be coupled to two other ICs: an 80C51-based microcontroller with 32k on-chip Flash memory (P89C662) and a real-time clock chip, PCF8563. This article
does not offer a complete design solution - it merely offers the reader some food for thought concerning a multi-protocol design concept.

The devices chosen offer the features needed to complete this design concept. The P89C662 was chosen because it offers on-chip Flash memory and a I²C-Bus interface. The Flash memory allows the microcontroller to be programmed after the product has been fully manufactured, via a special in system programming (ISP) function; and the I²C-Bus interface is needed to communicate with the PCF8563. This real-time clock chip was selected because of its ultra-low current consumption and wide supply voltage options. The device offers calendar as well as time information, making it the ideal part to use in any application where date and time stamping or calculations are required.

This includes season tickets (transport and stadium access), specifically timed access (e.g., during games only), etc.; and a digital part of the CLRC632 to enable the device to handle the complete ISO14443 framing and coding, etc.; and a digital part which handles the complete ISO14443 framing and error detection (CRC).

The device can be connected to a microcontroller or processor via a standard 8-bit parallel interface.

Multi-protocol operation
A number of registers are used in the digital part of the CLRC632 to enable the device to address and exchange data with tags employing different protocols.

For example:
- The clock rate, mode and transmitter framing conditions are set in the CoderControl register;
- The number of subcarrier pulses per bit, and ISO selection is achieved in RXControl1 register;
- Receiver framing and coding is set up in the DecoderControl register;
- CRC calculation and bit-length is determined by the contents of the ChannelRedundancy register.

The default power-on configuration for the CLRC632 enables Mifare and ISO14443. The device also supports all layers of ISO15693 and ICODE1. Demodulation and decoding of signals from ISO15693 and ICODE1 transponders is efficiently implemented by the receiver circuitry, while the digital part handles framing and error detection (CRC).

The internal transmitter part is capable of driving an antenna designed for proximity work up to a distance of 100 mm without the need of external drivers.

Mifare Classic security keys, named crypto1 keys, are to be stored in E²PROM in a predetermined format to ensure access to the data stored on the Mifare card.

Anti-collision
When two or more tags are present in the RF field at the same time, they will respond simultaneously. The CLRC632 employs a complex algorithm (dependant on the protocol used) to reliably and rapidly resolve data collisions. The CLRC632 is thus able to select one of the tags in the RF field, address it and exchange data with it only.

This device can address and exchange data with all versions of Mifare, including 1 k, 4 k, Ultralight, DESFire plus its interfaces on multiple interface smartcards.

Evaluation / demo kits
Philips offer a complete evaluation kit, CLRD 701, based on and using the CLRC632, for use by engineers developing hardware and by anyone wishing to demonstrate or explore the benefits of the Mifare or ICODE technologies.

Conclusion
The heart of this multi-standard or multi-protocol base station unit is the complex and highly integrated device CLRC632. The accompanying devices control it and assist it to provide a level of functionality that would make a highly sophisticated and flexible base station unit for use in almost any 13.56 MHz RFID application.

The design is simple yet powerful. It does not call for a large number of components, either simple or complex. The idea of using a microcontroller with on-chip Flash memory both increases flexibility and reduces the number of devices on the PC board. The real-time clock / calendar chip further adds functionality.

Full technical information on all of the devices discussed in this article is available from www.semiconductors.philips.com/products.

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