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**How new antenna-matching technology helps HF RFID designs perform reliably in difficult environments**

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One of the principal difficulties in the design of RF circuits is maintaining a good match between the antenna and the transceiver. Tuning a system in the laboratory might be convenient, but conditions in the lab rarely reflect the conditions that the system will experience in the real world. After installation, system performance can be greatly impaired by environmental conditions such as the proximity of metal or water.

High-Frequency RFID (HF-RFID) applications are vulnerable to this effect. Unfortunately, conventional HF-RFID components provide no means for the user to adjust the device to compensate for environmental conditions; trimming is a time-consuming, manual – and therefore expensive – process carried out at the factory.

HF-RFID systems, which operate at 13.56MHz, are governed by globally accepted standards:

- ISO14443 A/B (4,5) – Proximity or short range up to approximately 75mm.
- ISO15693 (6,7) – 'Vicinity' or mid-range up to approximately 1m.
- ISO18092 (8) – Near Field Communications (NFC). Used for communicating reader-to-reader or reader-to-NFC device.

Each standard defines the characteristics of the tag, including:

- Physical characteristics
- Radio frequency interface (ISO14443)
- Initialisation and anti-collision (ISO14443)
- Air interface and initialisation (ISO15693)
- Transmission protocols (ISO14443)
- Other protocols (ISO15693)
- Registration of applications/users (ISO15693)

It is possible to design a multi-standard reader so that it can communicate with any HF-RFID transponders (also known as tags). A reader will be capable of reading and writing to the tag. In ISO14443 and ISO15693 systems, the tag will be powered by the energy of the RF field broadcast by the reader (see Figure 1).

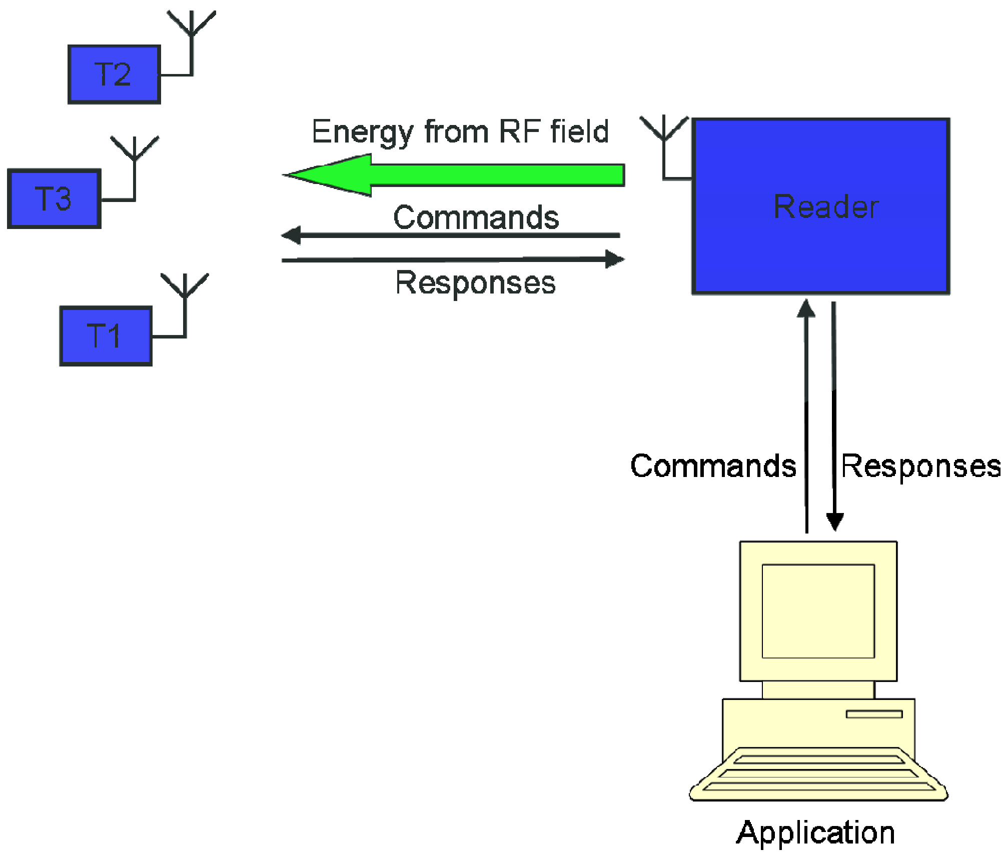


*Fig. 1: simplified architecture of typical RFID application*

The variety of standards for HF-RFID has evolved in response to the diversity of uses that organizations wish to make of it. For instance, RFID can be used both in fixed and mobile applications. In fixed installations, readers must be able to function in the presence of many different materials. In access control systems, for instance, the reader is generally located at a doorway; here, it could be adjacent to metal, glass, wood or composites, and each of these has different RF characteristics. Clearly, the reader's RF circuit needs a way to compensate for the effect of these materials so that it performs properly in every location. The environment might be different for handheld readers (as used in payment terminals, livestock tracking systems etc) – they must cope, for instance, with rain, humidity and the proximity of human and animal bodies – but the requirement for antenna trimming is the same.

The basic building blocks of an RFID reader are the antenna, RF section and controller. Good system performance requires a match between the RF section and the antenna. Since HF-RFID systems use an RLC tank circuit for the antenna system, antenna tuning is required.

The frequency of the tank circuit will be defined by the equation:

$$F = 1/(2\pi * \text{sqrt}(LC)) = 13.56\text{MHz}$$

The purpose of the resistor is to determine the bandwidth or Q of the tank circuit. This value merits careful attention. If the value selected is too small, then the signal will suffer from excessive attenuation. If the value is too large, then noise can be a problem. For ISO14443 for example, a Q of 13 is a good choice. This is because the bandwidth required is 848kHz ($F_b$). This is defined by the equation:

$$Q = F/F_b$$

The actual calculation should be for a Q of 16, the extra margin is desirable to minimize the attenuation of the signal.

The value of R can now be calculated. The desired value will be determined by:

$$R_D = Q * 2\pi FL$$

Since this is a parallel circuit, the effective resistances of the inductor and capacitor must be taken into consideration, so R can be calculated by:

$$R=1/((1/R_D) - (1/R_C) - (1/R_L))$$

Due to the tolerances of each of the components, the resonant frequency will have to be calibrated before the reader can be used. This is normally done by adjusting a variable capacitor designed into the circuit. This tuning process is time-consuming. Indeed, manufacturing engineers dislike manual processes because they are costly and vulnerable to human error. What's more, the environment in the production line is likely to be different from the environment in its final location, so the system might need to be re-tuned after installation. This requires more time and money before the system goes online. Lastly, adjustable capacitors drift over time and can take the system off-frequency.

A reader IC that automates the antenna tuning process as part of an easy-to-use, software-controlled system eliminates all these problems.

A good example of an integrated solution for a reader with automatic antenna management is the AS3910 HF-RFID reader IC from austriamicrosystems. Its main advantage for the system designer is that system tuning is performed digitally via a command sent from the system controller. Not only does software control simplify tuning, it allows the user to easily re-tune the system to improve performance in the field when needed.

Digital tuning is simple to implement. When the tuning sequence begins, an initial measurement is taken with the tuning capacitors disabled. If the system is not in resonance, then the capacitance is increased. This process continues until antenna resonance is achieved. In the AS3910, this process is implemented with just two commands, Check Antenna Resonance and Calibrate Antenna Resonance, which are hard-coded into the device. A phase detector is used to measure the phase shift between the transmitter output signals and the receiver input. When a phase shift of 90° is achieved, then the system is properly matched. The low-impedance output driver can be configured to direct-drive a single ended or a differential antenna system (see Figure 2).

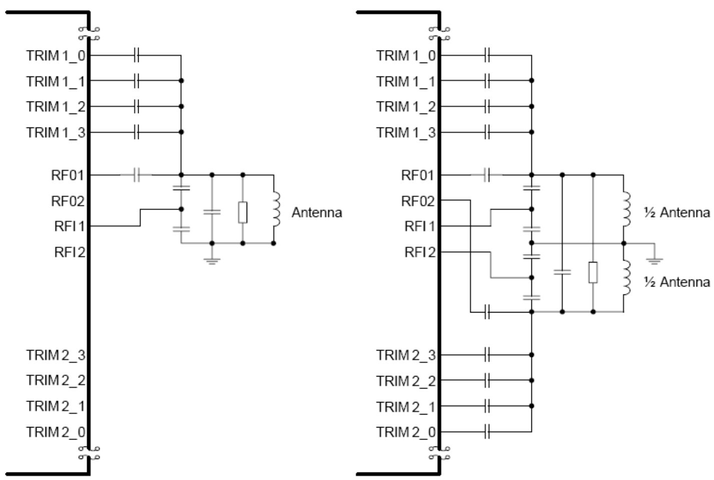


*Fig. 2: AS3910 can be configured to drive a single-ended or differential antenna*

The Calibrate Antenna Resonance command lets the user optimise antenna performance in a way that both simplifies the manufacturing process and allows some compensation for detuning in the field. When the command is first executed – with the trim capacitors disabled – the measured frequency will be higher than 13.56MHz. Next, the device switches in Trim1_0 and measures the resonant frequency. Each switch-and-test step takes approximately 10µs. Next, the AS3910 will switch in the trim capacitors until a resonant frequency of 13.56MHz is achieved.

Ideally, this will be achieved with trim capacitors 2 and 3 inserted. This allows for adjustment either higher or lower should the antenna become detuned. The positions of the trim capacitors that are being used for resonance are stored in the antenna calibration register. If, after switching in all the trim capacitors, resonance cannot be achieved, the antenna calibration register displays an error flag alerting the user that there has been a calibration error and that the system should be checked.

**Lowering cost and improving performance**

Digital calibration of the RF circuit in HF-RFID readers has the virtue of improving RF performance in environments that are hostile to RF, at the same time as lowering the manufacturing cost of the product. As the AS3910 shows, it is possible to implement digital trimming with elegant and simple software controls. Electronics manufacturers everywhere constantly strive to automate basic processes: RFID antenna tuning, surely, is another manual process that should soon become history.

*For more information about austriamicrosystems' products for RFID applications, including the AS3910 IC, visit www.austriamicrosystems.com.*