

ABSTRACT

Communication between a contactless reader and a proximity card is done through inductive coupling. Reader's antenna emits a magnetic field (13,56MHz nominal frequency) ; card uses this magnetic field as its power source (transformer principle). In the same time, modulation of the field carries a half-duplex data stream between both devices. Therefore, the quality of coupling between card's and reader's antennas is the critical part of the system.

Pro-Active devices ship with an antenna tuning that accommodates most common cards in an "open field" environment. When working with some cards, or when the reader is not installed in a perturbed environment, on-the-field tuning may be required. This application note explains how this tuning can be achieved without specific measuring instruments.

In its first part, this application notes also deals with environmental influences, and shows countermeasures that may be needed to have reader working in a perturbed environment.

ENVIRONMENTAL INFLUENCES

INFLUENCE OF METAL

Problems

The 13,56MHz magnetic field induces an eddy current in the metal positioned nearby the antenna (Foucault currents). This causes both a loss of energy (part of the energy provided by the reader is dissipated as heat in the metal instead of being available for the card) and a detuning of the antenna. The consequences of these effects are a reduced operating distance, and frequent transmission errors.

For this reason, it is required to keep reader's antenna far from any massive metal component (PCB shielding, housing of the product, metallic table, armed-concrete wall...). Generally speaking, the operating distance of the reader will always be shorter than the distance between antenna and metal (in any side of the antenna).

Tuning the antenna

Wherever a massive metal component is located less than 10cm from the antenna, a specific tuning shall be performed *in the actual operating environment*.

If you're integrating Pro-Active OEM devices, keep in mind when designing the final product that tuning of the antenna shall remain possible with all components in the finally intended position.

Using a ferrite shield

If metal has to be placed very close to the antenna itself (less than 3cm), a ferrite shielding should be used to limit the effects of the disturbance. Calculating the optimum position and dimensions of the ferrite plane is very hard ; experience shows that two options give interesting results :

- Ferrite plane glued directly at the back of the antenna, with approximately the same dimensions (ferrite shall overlap a few millimeters the antenna coil). This is the only choice when there are numerous metal components at difference distances in antenna nearby.
- Ferrite plane glued on the metal itself. This option is interesting when there's a single (and flat) metal item in the nearby, for example a shielding plate or a housing. In this case, the ferrite shall cover the whole metal surface (metal item smaller than antenna) or overlap antenna coil 2 to 3 centimeters in each direction (metal item bigger than antenna).

In both cases, a specific tuning has to be performed after ferrite is added.

INFLUENCE OF OTHER READERS

Problems

Contactless operation involves inductive coupling between card's antenna and reader's antenna. If two readers are positioned close to each other and are active on the same time, communication with the card is often impossible due to out-of-phase signals and collisions in data streams. If one of the readers is switched off, its antenna remains coupled to the other's. This causes both a detuning of the active antenna and a reduced operating distance due to the energy lost in the passive antenna and its matching circuit.

Requirements

Distance between two readers operating at 13,56MHz shall be at least 30 cm if they both are shielded (ferrite on the back of the antenna), and at least 10 times the antenna radius if they are not shielded.

If two readers have to be closer than this distance, they shall never be active simultaneously. Tuning of both antennas has to be done carefully but can not overcome the reduced operating distance.

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APPLICATION NOTE

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INFLUENCE OF TEMPERATURE

Temperature affects electrical parameters of the antenna itself and of its matching circuit. Pro-Active devices are built from components with a low-temperature coefficient. The influence of temperature can therefore be neglected when reader is installed in a "current" environment. Anyway, if the reader is always operated at a temperature below 5°C or above 35°C, a specific tuning can be done to increase a little the operating distance.

TUNING OF THE ANTENNA

PHYSICAL BACKGROUND

Roughly speaking, the contactless antenna and its matching circuit is an R, L, C circuit (resistor, inductance, capacitor) that forms a band-pass filter for both transmission and reception.

- R is a constant (physical characteristics of the antenna + soldered components).
- L has a constant part (physical characteristics of the antenna) and a variable part that heavily depends on the operating environment.
- In Pro-Active's devices, C is the variable part, by the mean of an adjustable capacitor.

Altering C has two combined effects :

1. It alters the resonance frequency (f_0) of the circuit,
2. It alters the quality factor (Q) of the circuit.

Tuning means finding the best compromise between both parameters f_0 and Q, so that the band-pass filter has a narrow resonance around 13,56MHz (for optimal energy transfer), and still is wide enough to pass the carrier frequency and the side-bands holding the data streams.

LIMITATIONS AND DISCLAIMER

The tuning method described here is only an iterative process that can be done without measurement equipments. Instead of a reference antenna exactly accorded at 13,56MHz, we will use only contactless cards. Since contactless cards antenna are not accorded exactly at 13,56MHz, but at a value that can be as high as 19MHz to allow "stacking" of multiple cards, this method may lead to a reader working very well with some cards, but totally unable to communicate with others. Therefore, if you're working with multiple card types, we do not recommend using this method. Please review Philips' application notes and consider buying appropriate measurement instruments if you need to tune your antennas in such a situation.

MODE OF OPERATION

You'll need at least 2 proximity cards to do the tuning, 1 non-metallic screwdriver (*tuning screwdriver*), and

Locate the adjustable capacitor near the contactless antenna. *Note that products with housing (CSB, SpringProx, ...) must be opened to get access to the tuning capacitor.*

1. Power on the reader.
Connect to the reader with a terminal emulator (such as HyperTerminal).
Enter the command "poll".

Move the first card in front of the antenna until the serial number of the card is displayed.
2. Put the first card at a distance that is equal to the diameter or the biggest dimension of the antenna (for a CSB4, this is 7cm). Turn the adjustable capacitor slowly, *always clockwise*, until the serial number of the card is displayed. If serial number is not displayed after a complete turn, decrease the distance by 1cm.
3. Continue to turn *always clockwise* until the serial number of the card is not displayed anymore. Turn back just a little to retrieve the serial number.
4. Put the first card directly on the antenna (distance = 0cm). If needed trim the adjustable capacitor *anti-clockwise* until serial number is displayed again. Remove the first card. Put the second card directly on the antenna and also turn the adjustable capacitor *anti-clockwise* if needed. Remove the second card.
5. Put both cards one after the other at "typical" operating distance (for a CSB, this is the thickness of the housing). Check that serial number is displayed.
6. Put both cards in the same time at "typical" operating distance. Both serial numbers should be displayed alternatively. If not, trim the adjustable capacitor *anti-clockwise*.
7. Check that both cards are now seen from distance = 0cm to at least distance = biggest antenna dimension divided by 2.

In case this procedure fails (unable to achieve step 2, 5 or 7), firstly try to apply the same procedure with different cards. Due to dispersion in card's characteristics, tuning can be easier with one card than with another one supposed to be identical. If still unsuccessful, please contact our support team to discuss antenna placement, shielding, resizing...

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