Contactless Identification Device With Anticollision Algorithm

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Abstract: An anticollision algorithm for radio frequency based communication with passive contactless identification devices is realized. The anticollision algorithm is based on a bit-wise arbitration during the identification phase of the target device. The identification time of a unique device is independent of the number of devices which are actively involved in the identification process (keywords: RF-ID, smart-card, anticollision contactless identification devices). CSCC'99 Proc.pp.4451-3456

Introduction: Radio frequency (RF) based passive contactless identification devices is an emerging technology which influences a lot of different application domains. It lets the end user identify an item so that it can quickly and accurately re-identified, electronically, as it moves through the distribution/utilization process. RF-ID chips may not only be used as simple identification devices, but as more complex personal data recording devices or in sophisticated smart card applications. The implantation of small RF-ID chips in animals for example helps to observe their migration or disease propagation. RF-ID chips in clothes for example helps in large laundries to organize the individual washing procedure and to identify their owners. Access control by RF-ID chips in buildings instead of ordinary keys are much more flexible and thus quite common, access control at ski-lifts are much faster. RF-ID chips are also used to identify and to keep track of stock or production units. Recent document management systems can not only handle digital data, but are also able to identify physical archived files, which are equipped with RF-ID chips. The wear out of tools and machine units can be kept track with RF-ID chips. RF-ID technology may replace bar codes on food stores, record over-temperature of sensitive food, or for applications like automatic billing and refilling in mini-bars of hotel rooms. More sophisticated applications use so called smart cards with integrated encryption processor power. Applications in the domain of electronic cash are quite common. Intelligent tickets mixing access for concerts, sport events, fitness room every morning, ski-lift every afternoon may improve customer service.

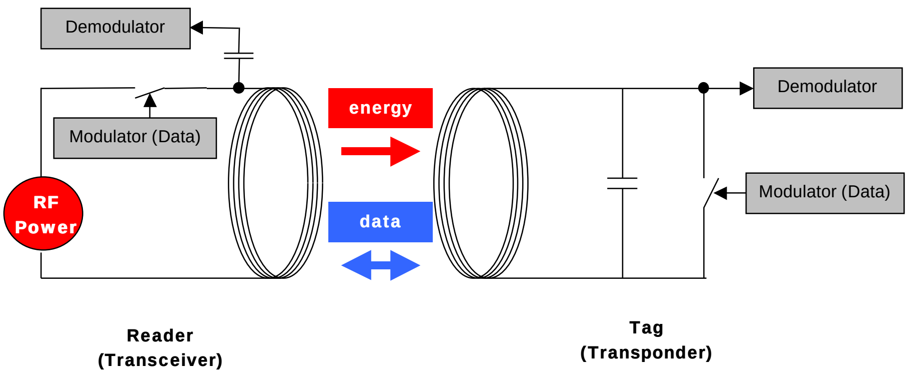


Fig 1: The reader transmits the energy to the tag by means of an electromagnetic field.
Data communication in both directions is performed by modulation of the electromagnetic field.

RF-ID systems basically are made of a transceiver (reader) and a transponder (tag). The transceiver is the active unit, which is able to read information from a transponder or to write information into a transponder. The transceiver generates an electromagnetic field with its antenna. Quite common frequencies are 125kHz and 13.56MHz. The transponder extracts its energy from the electromagnetic field with its antenna by charging a capacitor until the chip is able to operate. After having transferred the energy to the transponder, the transceiver and the transponder may now exchange information by modulation methods like amplitude modulation (AM), pulse shift keying (PSK) or frequency shift keying (FSK) of the electromagnetic field.

General Anticollision Algorithms

Some of the contactless identification device applications require communication with multiple RF-ID devices simultaneously or selectively. In order to communicate with a single device out of a group of devices, the target RF-ID device has to be identified prior to be able to be addressed. Therefore the reader has to start a call like “who is there?”. Now all tags may answer simultaneously with their identification codes. The process to distinguish between all these answers and to capture their identification codes correctly is called anticollision process. There exist different anticollision methods to identify a device within a group. The anticollision algorithms may explore the spatial domain, the time domain or the frequency domain in order to identify multiple tags. One possibility based on the time domain is to use RF-ID transponders with random response times. If there are not too many transponders simultaneously in the electromagnetic field, the probability to identify a first device before a second interferes is quite high. The disadvantage of this method is that the maximal number of transponders in the field is highly dependant of the distribution of the random response time. Thus the identification time of a device depends on the number of possible devices in the field. There exist other algorithms, where the transponders in the field are allowed to answer simultaneously. Powerful signal processors in the transceiver unit are then used to separate and to identify the different responses. The complexity of the transceiver unit may here be judged as a disadvantage.

Bit Arbitration Based Anticollision Algorithm

As soon as a transponder is known by its identification code, a selective communication with a known transponder is not a problem anymore. Therefore a powerful anticollision algorithm is crucial in order to get the identification codes of transponders in or entering the electromagnetic field. As we investigated in a document management system research project where numerous transponders on physical files are simultaneously in or removed from the electromagnetic field, a fast anticollision algorithm with constant response times independent of the maximal number of simultaneously present transponders was crucial to the application. In order to achieve these goals, a bit arbitration based anticollision algorithm was developed, which can be compared to the binary search three methods exploring the time domain.

The anticollision process to identify a single transponder out of a group of transponders is performed by our so called arbitration process. All unidentified transponders in the electromagnetic field are classified as active at the beginning of an arbitration process. Active transponders will take part in the arbitration process. Newly entering transponders during an ongoing arbitration process will not take part in the arbitration process. The arbitration process itself is a repetition of the following bit-arbitration step until one of the transponders is identified.

Bit-arbitration step:

A bit-arbitration identifies one bit of the identification code of one or a group of transponders. The bit-arbitration proceeds as follows: Upon a request from the transceiver, all active transponders send the value of a given bit-position of their identification code. Logical “0”s or “1”s of the transponders response are located in two different time slots. Thus the transceiver can recognize, if there are transponders answering with a logical “0” or others answering with a logical “1” (BitVal). The transceiver may now select one of these two transponder groups by sending a continue command frame where he informs the transponders with the “0” (or “1”) answer (ContBit) to continue an other bit-arbitration step. Transponders whose bit value of the identification code did not correspond to the transceivers response value immediately quit the actual arbitration process and wait for a new command while remaining in the active group. All other active transponders are requested to proceed with another bit arbitration step to identify the next bit of their identification code.

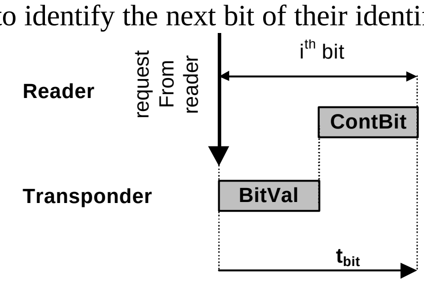
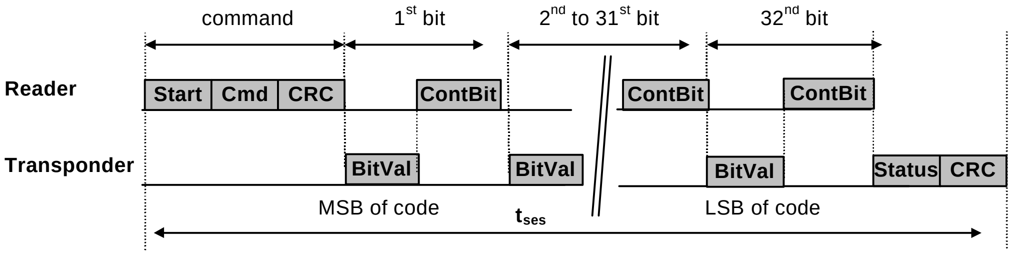


Fig. 2: Arbitration step for one bit.

The bit-arbitration steps are repeated until all bits of the identification code of one transponder are recognized. Thus the identification time of the bit-arbitration based algorithm is independent of the number of transponders in the electromagnetic field, but linearly dependent of the identification code length. With each arbitration process one unknown transponder is identified.



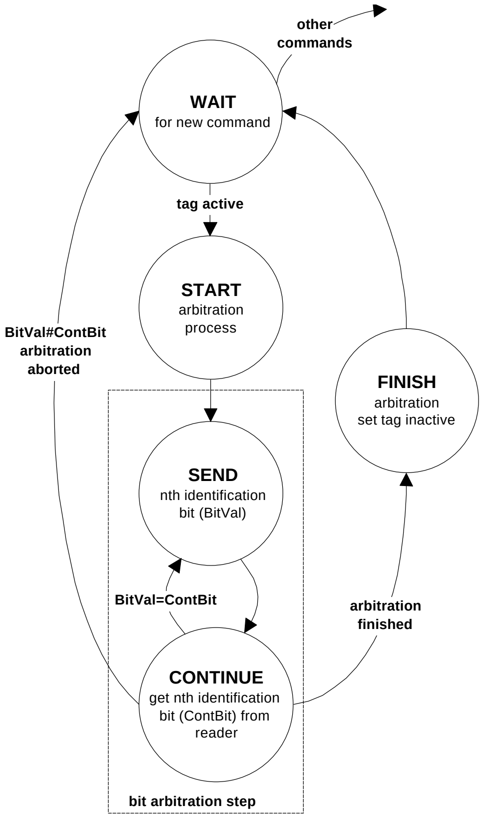


Fig. 3: A full arbitration process consists of N=32 bit-arbitration steps as well as start and end frames.

Fig. 4: Flow chart of the arbitration process. The n^{th} identification bit runs from the 1^{st} to the maximal number of bits of identification code.

Modulation of transponder answer during bit-arbitration step:

During the bit-arbitration step, the different transponders all answer synchronously at the same time. As the response value of the different transponders is coded with the time position of the modulation, no answer conflicts are generated. The transponders answer (BitVal frame) for a logical “0” thus may be interpreted like sending a 4 bit sequence coded “00ZZ” by field modulation. The Z value may be interpreted like a high impedance logic value Z which corresponds to no modulation at all. The figure below illustrates how the transponder modulates the electromagnetic field of the transceiver in order to send the above “00ZZ” answer sequences during the bit-arbitration step.

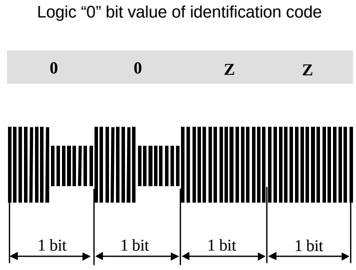


Fig. 4: Transponder sends a logic “0” bit of its identification code bit, which is done my modulating the field at a given time position (“00ZZ” BitVal frame).

The transponders send a logical “1” as identification code bit during the bit arbitration step as a sequence which may be interpreted like sending the modulation sequence “ZZ00”.

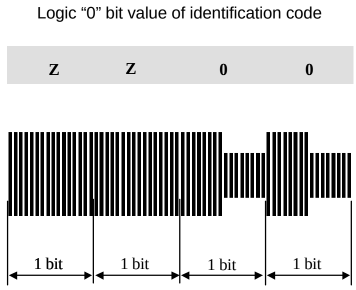


Fig. 5: Transponder sends a logic “1” bit of its identification code bit, which is done by modulating the field at a given time position (“ZZ00” BitVal frame).

If there is just one transponder answering, the transceiver can read the answer value without any problems. If two different transponders are answering with the same logical value, the transceiver will also be able to read the value correctly as all answers are synchronized. If several transponders are answering with different logical values, the transceiver will read the modulation value “0000” which he correctly interprets as receiving a logical “0” as well as a logical “1”.

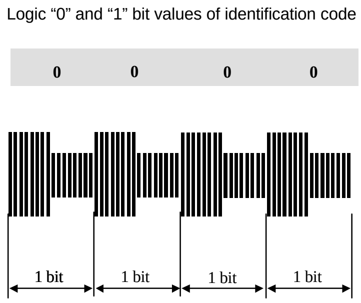


Fig. 6: Different transponder send a logic “0” and logic “1” bit of their identification code bits simultaneously (superposed “ZZ00” and “00ZZ” BitVal frames).

System Description

We are currently integrating the MicroLab-Tag transponder with a 1μm CMOS technology from EM microelectronics with the described bit-arbitration based anticollision algorithm. In addition to the arbitration command we implemented, some additional commands like “general read” for reading the identification code of a single transponder in the electromagnetic field, “general read of active items” for reading a single active transponder within a group of inactive transponders, “selective read” for selective addressing a known transponder within a group, “selective toggle” for changing the active/inactive status of an addressed transponder within a group.

The communication protocol is optimized for maximal distances between reader and tag and for minimal energy storage capacitance on the tag. Our transponder got a 300pF capacitance which could be integrated on the transponder chip. Therefore there is no need for an additional external capacitance for the tag which reduces the overall tags cost. During the modulation time no energy can be transported to the transponder. Thus optimizing the protocol with the energy saving objective leads to a bit coding with only short modulation times. The figures below illustrate the modulation of a logical “1” (during 1/8 period modulation), a logical “0” (during 2/8 periods modulation) and a special start bit.

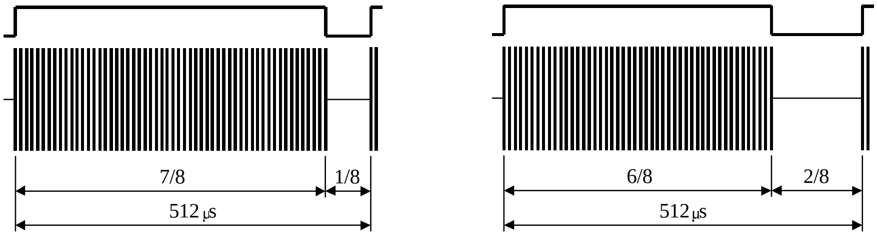


Fig. 7: Modulation protocol of 125kHz for transmitting a logic “1” (left) and logic “0” (right) to the transponder.

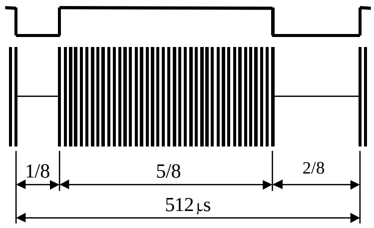
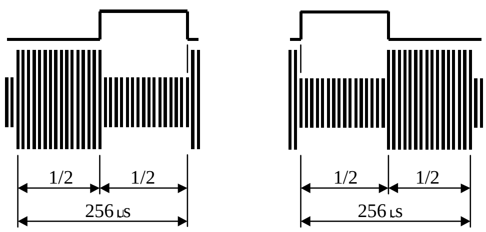


Fig. 8: Modulation protocol of 125kHz for transmitting a start bit from transceiver to transponder.

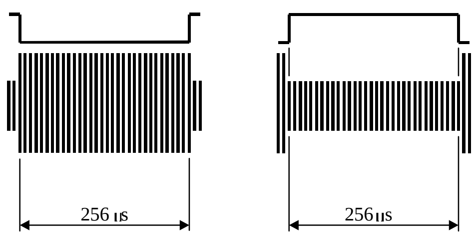
As one bit lasts 64 periods of the 125kHz electromagnetic field generated by the transceiver, the data rate from the transceiver to the transponder is 2kBits per second.

In the opposite direction from transponder to transceiver, there is normally not a 100% modulation. Nevertheless the maximal modulation time should also not exceed 16 periods of the 125kHz frequency in order not to loose the transponders energy too fast. Using a conditional diphase coding schema, the data extraction at the reader is quite simple, because the synchronization to the data stream can be done by the data itself. Between each bit of a conditional diphase code there is a change in modulation. A logic ‘0’ differs from a logic ‘1’ with an additional change of phase in the middle of a bit. The conditional diphase code of the modulation protocol from the transponder to the transceiver is illustrated below:



or

Fig. 9 : Conditional diphase modulation protocol of 125kHz for transmitting a logic “0” to the transceiver.



or

Fig. 10 : Conditional diphase modulation protocol of 125kHz for transmitting a logic “1” to the transceiver.

As one bit lasts 32 periods of the 125kHz electromagnetic field generated by the transceiver, the data rate from the transponder to the transceiver is 4kBits per second.

The figure below shows the block diagram of the transponder. A dedicated clock extractor is able to extract the clock from the 125kHz electromagnetic field even if the transponder is modulating the field. A low and a high threshold level are activated, depending if the field is modulated by the transponder or if it is not modulated.

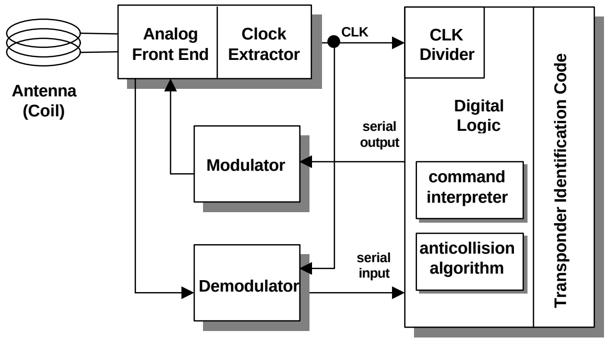


Fig. 9: Block diagram of anticollision transponder

Results and Conclusion

A bit arbitration based anticollision algorithm for amplitude modulated RF passive contactless identification devices is realized. The identification time of a unique device is independent of the number of devices which are actively involved in the identification process. Thus no optimization for a given number of tags in a field need to be done as it would be necessary with random based time response algorithms. The time needed to identify a single transponder out of a large group of transponders is deterministic and linear to the number of identification bits. With the implementation protocol at 125 kHz frequency, 7 tags can be identified within one second, supposing a 2 kBit data rate. At 13.56 MHz supposing a data rate of 64 kBits, 220 unknown tags can be identified within one second. Due to the protocols and the bit coding schema, very low cost readers with anticollision features can be realized.

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