

Animal Radio Frequency Identification: Low Frequency Advanced Transponder with flexible memory organization

P.H. Hogewerf, C. Aslanidis***

**IMA-Wageningen, P.O. box 397, 6700 AJ Wageningen, The Netherlands*

*** Texas Instruments Deutschland GmbH, Haggertystrasse 1, D-85356 Freising, Germany*

Abstract

The low frequency advanced transponder animal identification standard ISO 14223 has three parts:

- Part 1: Air Interface;
- Part 2: Code and Command Structure;
- Part 3: Applications.

The part 3 offers the possibility to tune memory organization and memory sizes to application requirements. The composition of the memory shall be defined by authorities or user groups. The number written in the Data Format Identifier (DFID) field (65536 possibilities) is the indicator of the authority responsible for the memory definition for that DFID. The WWRRA (worldwide registering of registration authorities) is responsible for the granting and publication of DFID's.

The advanced transponder memory is split in the following parts:

- ISO 11784 and ISO 11785 part. The coding is defined in the standards ISO 11784 and ISO 11785.
- DFID link: a block divided into two parts of both two bytes. The last two bytes are used for the DFID code [00000..65535] and the first two bytes are reserved for future use (RFU). The DFID code is the link to the authority responsible for the definition of the memory configuration, size and content.
- Single Access Memory (SAM) section is optional. In case SAM is used the DFID authority shall define the content the SAM.
- Data Directory driven Memory (DDM) section is optional. In case DDM is used the DFID authority shall define the size of this DDM memory and provide information about the Object Identifiers (OID's).

This user defined memory organization allows the best of both: fast data access for the SAM part (e.g. data accessible if an animal passes a reader) and flexibility for the DDM part (e.g. database information can be recorded in this part).

The ISO 14223 memory organization of transponders with a reserved DFID code is pre-defined (DFID data, SAM and DDM). An overview of the reserved DFID's and the memory organization of those transponders is given in ISO 14223 part 3 annexes.

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Introduction

The development of the Radio Frequency Identification (RFID) systems started at the end of the 1960ies (Rossing, 1999). Results of institutes in the UK, Germany, the Netherlands and

the USA were reported at the symposium 'Cow Identification Systems and their Applications', held in the Netherlands in April 1976 (Anonymous, 1976). The first commercial (dairy) animal identification systems became available shortly after this symposium. At the end of the previous century, in several countries, there were already a high percentage of dairy cows equipped with a transponder on a collar around the neck.

Nowadays in most EU countries it is compulsory to identify pets and horses with an injectable transponder, basically for animal health control reasons, including public health (i.e.: rabies). Regulations have been introduced in many countries for the traceability of the origin and the movements of farm and also companion animals. They enable animals to be tracked during a disease outbreak and residual (e.g. dioxin) discovery at slaughter. In case of subsidizing schemes, individual animal identification can be an important tool for discovering fraud. Many of the identification schemes are based upon RFID (Hansen, 2011).

There is a worldwide market for food animals and companion animals that pass borders frequently (e.g. during a vacation period for pets), and therefore the traceability of animals is an international concern, as well as the compatibility of electronic animal identification devices. The need of international standards was recognized already in the nineties, and the first meeting of the International Organization for Standardization (ISO) around animal identification was organized in 1991. In 1994, a resolution was approved by the ISO to start the standardization of electronic identification for all categories of animals (including fish).

In close cooperation with the manufacturers of RFID technology (manufacturers of Integrated Circuits; IC's, transponders and readers) and RFID user group organizations (all formally representing national standardization bodies), ISO is developing standards for animal identification. In 1996 the animal identification standards ISO 11784 and ISO 11785 were published. The code structure of the ISO11784 and ISO 11785 standards include the following fields: animal bit, country code (3 digits), identification code (12 digits), retag counter, user information field, reserved field, RUDI bit and trailer bit. The ISO11784 and ISO 11785 transponders are programmed during manufacturing or have a one time programming possibility. The purpose of these transponders is to be the link between the animal and information of the animal inside a database. The ISO11784 and ISO 11785 transponder itself does not have the possibility to store information.

In some applications additional transponder features are appreciated, so the ISO working group on animal identification initiated the development of standards for advanced transponders, ISO 14223. The additional features are the possibility of storing (user) information on the transponders and the possibility of reading information while having several transponders in the field of the reader. This anti collision mode of the advanced LF transponders will only work with populations of advanced LF transponders. It will not work in a mixed population of advanced and non advanced LF transponders, because the responding of the non advanced LF transponder cannot be switched off. The anti collision mechanism is time consuming what makes this method a little less suitable for dynamic reading conditions (e.g. group of quick moving small animals). For the user it is important that the id-codes of the advanced transponders can also be read with the installed reader base, so the advanced transponders conforming to the ISO 14223 are compatible with ISO 11784 and ISO 11785 standards. This means that when an advanced transponder is activated it will first react with the ISO 11784 ID-code using the ISO 11785 air interface protocol.

The ISO 14223 standard has three different parts. The first part describes the air interface, the second part the code and command structure and the last part is focussing on applications. The development of the ISO 14223 part 3 put the ISO working group animal identification for a dilemma. From one side the market is demanding a lot of flexibility of the technology so that the technology can be used for different applications and from the other side as long as nothing has been specified it is impossible to develop equipment (e.g. readers) that can be used in the field. This document gives an overview how this dilemma has been solved by the ISO working group.

The application part of the ISO 14223 transponder

The application part of the ISO 14 223 describes the kind of information that can be stored in the advanced transponder memory, its format and the procedures how to access such information. There are four different memory parts accessible:

- In the fixed memory part:
 - The ISO 11785 information.
 - The data format identifier information.
- The user part of the memory has two sections:
 - one section of fixed allocation for defined information;
 - the other section is to be used with object identifiers in order to have maximum flexibility.

The content of object identifiers and the interface with other standards, such as ISO 11788 Data Dictionary is not included in the ISO 14423-3 standard.

Memory organization

ISO 14223-3 allows several methods of transponder memory organization and also allowing different sizes of memory (Table 1). Memory organization and size can be tuned to application requirements.

The composition of the memory is defined by agencies. The number written in the Data Format IDentifier (DFID) field is the indicator of the agency responsible for the memory definition used in combination with that DFID. The DFID allows the possibility of 65536 different agencies. The WWRRA (worldwide registering of registry agency) is responsible for the granting and publication of DFID's, e.g. ICAR could be appointed as WWRRA.

The memory of the ISO 14223 advanced transponder is split in the following four parts:

- ISO 11784 and ISO 11785 defined part. All ISO 14223 transponders are conforming to ISO 11784 and ISO11785. The coding of this memory part of the ISO 14223 transponders is defined in the standards ISO 11784 and ISO 11785.
- Data Format IDentifier (DFID) link. A block divided into two parts of both two bytes. The last two bytes are used for the DFID code [00000..65535] and the use of the first two bytes are reserved for future use (RFU). The DFID code is the link to the agency responsible for the definition of the memory configuration and the content of transponder coded with that DFID.

- Single Access Memory (SAM) section. The use of the SAM section is optional. In case SAM is used: the DFID Agency (DA) shall define the content of this SAM memory.
- Data Directory Memory (DDM) section. The use of the DDM section is optional. In case DDM is used: the DA shall define the size of this DDM memory and provide information about the Object Identifiers (OID's) used.

The ISO 11784 and ISO 11785 defined part and the DFID link are mandatory for ISO14223 transponders. The SAM and DDM sections are both optional.

Memory organization of the ISO 14223 advanced transponder indicated in blocks (one block is 4 bytes is 4 times 8 bits):

1. ISO 11784 & ISO 11785 part (defined in ISO 11784 & ISO 11785).
2. Block 0: Data Format Identifier (DFID) link.
 - Two bytes RFU
 - Two bytes for indicating the DFID of the responsible DA.
3. Block 1 .. N+M: is split in two optional parts
 - SAM section (1 .. N, with N=0 there is no SAM section)
 - DDM section (N+1 .. N+M, with M=0 there is no DDM section)

All blocks (0 .. N+M) can independently of each other be lock (or remain open). Information that has been locked can NOT be unlocked. The use and content of the SAM section and the DDM section is defined by the DA; DA Defined (DAD).

Table 1: Memory organization of the ISO 14223 transponder.

| Section | Mandatory | Block # | Byte 0 | Byte 1 | Byte 2 | Byte 3 | Lock bit |
|-------------------------------|-----------|---------|--------|--------|--------|--------|----------|
| ISO 11784 / ISO 11785 defined | | | | | | | |
| DFID link | Yes | 0 | RFU | RFU | DFID | DFID | Yes |
| SAM | No | 1 | DAD | DAD | DAD | DAD | Yes |
| | | .. | | | | | |
| | | N | DAD | DAD | DAD | DAD | Yes |
| DDM | No | N + 1 | DAD | DAD | DAD | DAD | Yes |
| | | .. | | | | | |
| | | N + M | DAD | DAD | DAD | DAD | Yes |

Organization responsible for maintaining ISO 14223.

In relation to maintaining of the ISO 14223-3 standard two organizations are relevant:

- WWRRA: Organization responsible for the worldwide registering of organizations responsible for the definition of the content of the user defined part of ISO 14223 transponders. This WWRRA is responsible for the granting of DFID's to these organizations and maintains a webpage mentioning the DFID's granted in combination with organizations responsible for the content definition of the user group defined part of the ISO 14223 transponder. The WWRRA is worldwide responsible for the granting of DFID's.
- DA: Agency (e.g. company, user group representative, governmental competent authority,) maintaining a register defining use and content of the user defined part of the ISO 14223 transponders. The content defined shall be used in combination with the DFID number granted to that DA. The content definition informs transceiver

manufacturers about the interpretation of data (when reading) and correctly formatting information (when writing data into transponders).

Table 2: Overview of DFID codes.

| DFID Code | Definition | Owner | Comment |
|------------------|--|--------------|--|
| 00000 | RFU | ISO | |
| 00001 | No additional Memory defined | User | |
| 00002 | Proprietary | User | Open format. |
| 00003 | DDM Only | ISO | Continuous stored data using the index for every item prior to the data. Standardized DDM Format |
| 00004-01000 | RFU | ISO | |
| 01001 | ISO Pre-defined DFID, General Animal | ISO | Fixed defined data agreed and managed by the ISO group. |
| 01002-02000 | RFU for Pre- defined DFID's | ISO | |
| 02001-65535 | User DFIDs | User | To be granted and published by WWRA |

Use of the user defined memory

There are four methods of using the user defined memory part (SAM and DDM):

1. The advanced transponders have no (defined) additional memory in use (no SAM and no DDM). The user defined memory part of the advanced transponder is not available, remains unused or the use is proprietary. The only addition of a ISO 14223 transponder using this memory organization against the ISO 11784 ISO 11785 transponder is the availability of the anti-collision protocol and the possibility of exchange of the DFID link.
2. The content of the SAM part of the user defined memory part is predefined in the content definition of the DA. The memory plan of every ISO 14223 transponder with this DFID is exactly the same (sequence of data is fixed). If someone wants to read or write specific information, the predefined content allows the possibility of only accessing the information that needs to be accessed. This can be realized when an animal is in a more or less fixed position and only limited time (less than a second) is available for communication i.e. reading/writing information. Fast access to the desired data is necessary. This is realized by having specific data at a fixed location in the transponder memory.
3. The content of the user defined memory is defined by the DA as being data directory driven. In the data directory driven memory (DDM) any information may be stored as long as the community of users defines a key that specifies the kind of information. Such a key is called an object identifier (OID) and it contains as well information in which format the relevant data is stored. This implies reading or writing information when the animal is in a fixed position and there is sufficient time available for communication. DDM information has to be read sequentially, which makes the protocol time consuming.
4. The DA has defined a SAM user defined memory part and a DDM user defined memory part. The SAM section has a fixed length and shall therefore always be the

first user defined memory part. This way organizing the user defined memory allows the best of both: fast access for the SAM part and a lot of flexibility for the DDM part.

The DFID is the key to the memory organization of the user defined memory. The ISO 14223-3 has defined series of DFID codes, indicating how the memory is organized. Table 2 gives an overview of the different DFID codes.

Data access

For reading transponders for animal identification and information the following aspects have to be considered:

- In a mixed population of ISO 11785 and ISO 14223 transponders, both transponder types have to be readable by an ISO 11785 reader.
- Some information shall be available in a minimum read time, for example if these data are required for selection or process control.
- There shall be maximum flexibility in the kind of data to be stored, even for applications which are not known today.

As a consequence there are four different levels of communicating with the advanced transponder:

1. ID reading: A reading has to be performed time efficiently. This is the case - for example - when the animal passes an antenna in a raceway or if just the animal identity has to be checked. In this situation the ISO 11784 code - packed in an ISO 11785 data telegram - will be read only. In a raceway no guarantees can be given that anti collision mechanism will lead to high identification percentages. Not all animals will be identified in a case where the animals are passing the antenna in a shorter time than the reading of all the anti collision slots takes. In the identification code reading process the "Advanced Transponder" according to ISO 14223 acts in its default mode in the same way as an ISO 11785 transponder. During this identification code reading process also the trailer information is transmitted. This trailer may contain additional information (e.g. body temperature). It has to be mentioned, that in a mixed population of ISO 11785 and ISO 14223 transponder the communication between reader and ISO 14223 transponder is blocked through the presence of ISO 11785 transponders.
2. DFID reading: Reading has to be performed in the shortest possible time. This is the case - for example - when a group of animal pass an antenna in a raceway and individual animals have to be checked on bases of the DFID code. In this situation the DFID will be read without reading other information. Readers have the possibility to transmit the read 'block 0' command so that the ISO 14223 transponders directly transmit the block with DFID information (without having the necessity of first reading the ISO 11785 protocol).
3. Access SAM: The procedure to read a specific block of the advanced transponder memory, having a pre-defined content. In this procedure the reader sends the command to retransmit the content of a specific block of the memory (the content of that specific block is defined by the DA). This can be realized when the animal is in a more or less fixed position and only limited time (about a second) is available for communication i.e. reading/writing information. Fast access to the desired data is necessary. This is realized by having specific data at a fixed location in the transponder memory. These data may include:
 - date of birth

- sex, castration information
- registration database
- telephone number owner or contact

The number of SAM blocks (≥ 0) is defined by the DFID agency, each block has 32 bit.

The reader can address all the different blocks individually and

- either read the 32 bit data, or
 - write 32 bit into that block, or
 - lock the block, which means its content cannot be altered anymore.
4. Access DDM: This implies Reading or Writing information when the animal is in a fixed position and there is sufficient time available for communication. Any information may be stored as long as the community of users defines a key that specifies the kind of information. Such a key is called OID and it contains as well information in which format the relevant data is stored. So literally any kind of information could be stored; out of the wide range of examples only two are given here:
- Vaccination data
 - Animal motion on different properties

Data storage with Object Identifier

The general principle of using OID's is laid down in ISO standards for item management. The purpose of an OID is to allow the host application (or even the reader) receiving the OID plus data to unambiguously interpret the data element which immediately follows the OID. The OID has to give the information whether the following data string contains alphanumeric data, numeric only data, of variable or fixed length.

The ISO 142223 allows two methods of defining and using OID's.

1. OID's that are worldwide commonly defined. A list of OIDs has to be established, which is valid for all animal applications based on official data dictionaries. This approach grants maximum flexibility, as new data elements may be added as "Object Identifiers" as soon as required from the user groups.
2. OID's are defined by the DA responsible for the memory definition used in combination with that DFID.

A combination of both is possible.

The list of worldwide applicable OIDs for ISO 14223 shall be administered by an independent organization (e.g. the WWRRA).

Concluding remarks

The ISO 14223 part 3 is under development and is expected to be published as international standard in 2015.

The ISO 14223 standard and especially the application part opens the possibility of a market introduction of low frequency advanced transponders. The memory organization of the advanced transponder offers a wide pallet of different application possibilities. The fact that the technology is compliant with the installed base of ISO 11784 and ISO 11785 readers allows a smooth introduction of this new technology. Frequency characteristics are the same

as the ISO 11784 and ISO 11785 transponders so reading performance will be as good as the installed base of low frequency transponders.

The challenge for companies that want to market the technology is to find useful applications in livestock and/or in companion animals.

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