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Automation of a RFID test bench

The function of a RFID (radio frequency identification) system is determined by various factors of its given application environment. Field trials do not provide consistent experimental conditions to assess the impact of these factors. For the development of animal identification systems it is necessary to create a consistent and reproducible experimental environment. The RFID test bench presented is designed to test long range RFID systems such as ultra high frequency systems (UHF) in particular. Special attention was paid to the automation of data acquisition and data filing. Automation was attained by a control centre which supports test preparations and test executions as well as data filing in terms of a subsequent analysis.

Keywords

Automation, animal Identification, RFID, transponder

Abstract

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Electronic animal identification based on RFID technology is becoming more widely used in livestock sectors outwith the so far accepted application in dairy animal management. The main reasons for this are legal animal identification requirements but also voluntary applications as part of precision livestock farming. This has led to increased research interest in expanding application possibilities of electronic animal identification, its performance capacity and further development in general.

This study looks especially at identification systems featuring simultaneous detection of data from a number of transponders (simultaneous identification). Supporting such applications are RFID systems with wide reception range and high data transmission rates. The function of an RFID system in a particular field of use depends, however, on factors that can have destructive (interference levels) or constructive (reference variables) effects [1]. Knowledge about the effects of such influencing factors is therefore important for the development and assessment of animal identification systems. Field trials, however, do not offer the constant definable conditions required for determining effects of single or multiple influencing factors. Needed is the creation of a constant and reproducible environment wherein particular influencing factors can be precisely varied.

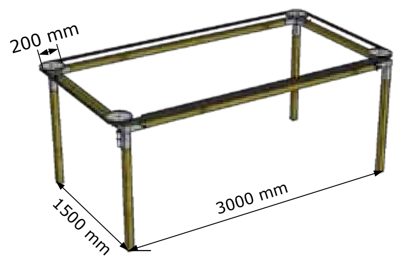
The aim in the development of the RFID test bench is creation of an environment wherein the effect of influencing factors on RFID systems information quality can be determined under constant and reproducible trial conditions. The test bench should be dimensioned in such a way that RFID systems with large ranges > 1m, such as systems in the ultra-high frequency (UHF) range, can be tested. In order to assess simultaneous identification ability the test bench should enable the passage of several transponders simultaneously in different orientations and at differing speeds through the reader field. Adjustments for different settings required for the trials should be able to be carried out simply and rapidly. Additionally, the recording and storage of data should be automated as far as possible.

Test stand construction

The developed test bench comprises a right-angled timber frame (3 000 x 1 500 mm) secured at the corners by metal elbow brackets which serve as supports for the axles and bearings of V-belt pulleys (25 x 9 000 mm). The measurements of the timber frame can be varied and must in total represent the length of the V-belt. One of the four V-belt pulleys is driven by a 24-volt direct current (dc) transmission motor (RE40/GP42C, Maxon Motor) allowing steplessly variable adjustment of V-belt speed. Plastic angles attached to the V-belt serve as holders for a quick-change system: different numbers and orientations of transponders can be attached to a plate on the V-belt. This arrangement enables all transponders under test to move at the same speed at a constant distance from one other.

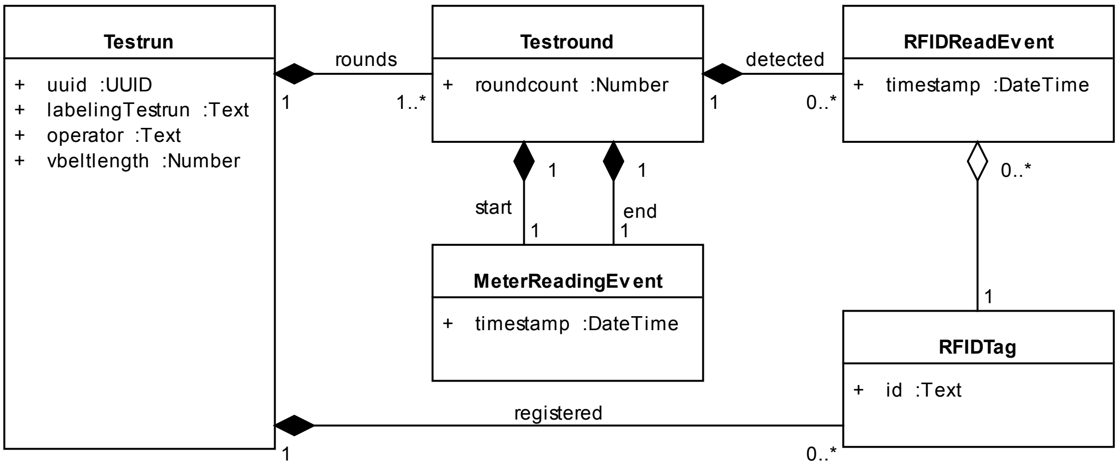
The V-belt direction of travel is on the horizontal plane (**Figure 1**). The reader antennae are so positioned under or over the V-belt that their main transmission direction is vertical. Through this positioning, RFID systems including those with greater range (> 1 m), can be tested without risk of transpond-

Fig. 1



RFID test bench with horizontal running direction

Fig. 2



UML domain model of the test run

ers being involuntarily read during the return journey in the opposite direction and with altered distances between them. Transponder identification takes place over a measuring track featuring a timber guide rail with a smooth polyvinyl chloride (PVC) coating so that the transponders can be moved through the recording length uniformly and without vibration. In order to be able to vary the distances between transponder and reader antennae, the antennae are placed on a height-adjustable wooden table especially built for the purpose. Above the measurement track can be placed a polyethylene (PE) container of water in order to determine the effect of the influencing factor water.

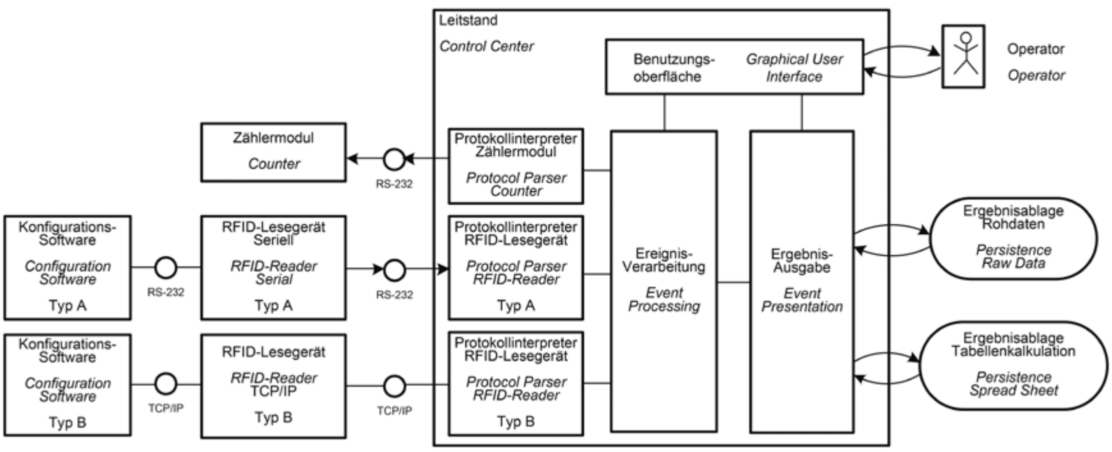
An electronic counter module (DLP-I020, DLP Design) records the number of rounds (circuits) on the bench, and thereby implicitly V-belt speed, using reed contacts and magnets fitted to the V-belt and V-belt pulley.

Automating the test bench

Test bench operation is supported by a control centre with dedicated software. The control centre is aimed at automating data recording as completely as possible while also guaranteeing persistence of the collected data so that the manual evaluation and processing for data analysis purposes is minimised.

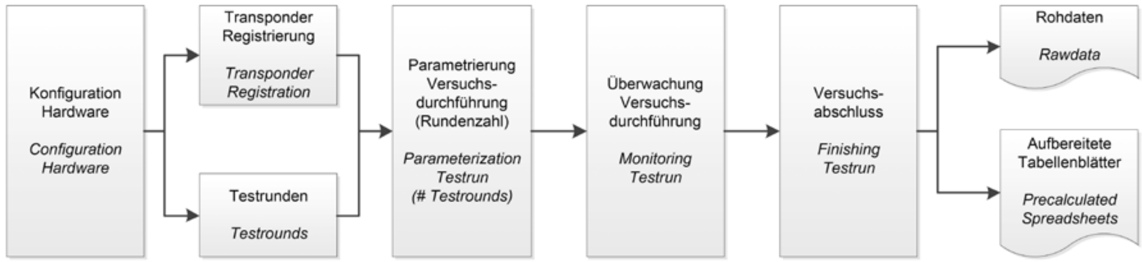
The pre-implementation requirement analysis results in establishment of a domain model (**Figure 2**) whereby a test run (Testrun) which can comprise a freely-chosen number of V-belt measurement circuits (Testround) is recorded with user-defined text (labellingTestrun). A surrogate key (UUID) is assigned to each test circuit. Every measurement circuit is consecutively numbered (roundcount) and referenced to the counter readings at beginning and end of the respective rounds (MeterReadingEvent) with an associated time stamp (timestamp). Through both time stamps (start/end) and the V-belt length of travel during the trial phase (vbeltlength) circuit time can be calculated. All the transponders recorded during a measurement circuit have the measurement circuit assigned (detected) as an event with time stamp (RFIDReadEvent). The transponders expected during a particular trial measurement are directly linked (registered) with this trial via their electronic identification number (EID).

Abb. 3



Control centre: software components and connected systems

Fig. 4



Schematic diagramm of the test procedure

The control centre is implemented in the programming language Java (Java SE 6) and works with a commercially available PC (**Figure 3**). The number reading on the circuit counter is cyclically read out via the serial interface RS-232. With every recorded increase a circuit result is calculated. RFID readers can be addressed from the control centre serially (RS-232) as well as via TCP/IP. So far, specific communication modules have been developed (protocol parser) for two separate RFID reader manufacturers (RRU4, Kathrein and UDL500, Deister Electronic). Additionally this system is open for extending with further readers. The RFID readers themselves are parameterised through manufacturer-specific configuration software.

The trial process is steered via the control centre user interface. The process is structured as follows (**Figure 4**): Firstly the necessary parameters for communication with the periphery instruments (circuit counter, RFID reader) set up and checked for proper functioning. Subsequently, the transponders in the trial are registered with the control centre whereby every transponder is individually identified manually. The control centre lists thereby the respective recorded results. After completion of the trial adjustments, as many test circuits as required can be carried out for testing the trial settings and making the transponders operation-ready. After this, the trial procedure is parameterised i.e. the number of desired measurement circuits are fed in and the trial recording started. During the trial the technologists can read off the relevant monitoring information:

- Circuit times
- Number of identified transponders
- List of identified transponders
- Etc.

At completion of a trial procedure, these are stored.

For every single trial procedure two files are stored. One file is produced in a way that is able to be interpreted by spread sheet program prepared to furnish the required information. On the other, raw data is stored as XML serialisation according to the already mentioned domain model (**Figure 2**).

Conclusion

With the test bench presented here the effect of influencing factors on RFID systems can be identified under constant trial conditions. It was conceived to test UHF systems and hereby demonstrates in comparison with [2] a horizontal running direction of transponders with vertical main transmission by the reader antennae as with [3]. Contrary to [3], however, the transponders move continually as in [2]. The trial settings can be varied simply and rapidly. The specific control software supports all three phases of the trial procedure: test preparations, trial procedure in a strict sense and analysis of collected data. Through the continuous feedback during trial preparations and procedure, errors can be reacted to immediately. The data storage spreadsheet programs optimised for data analysis support accelerated processing of the raw data and contribute also to quality assurance whereby manual working steps such as copying and inserting are avoided.

The test bench described here and its control centre software offer further optimising potential: currently, trial series to be processed are still planned and documented without the control centre software. Integration in the control centre of a module for trial series planning and conducting would therefore be helpful. The filing of the results could be extended by a database management system that enables specific evaluations and with which a specific statistical software could be directly linked.

Literature

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