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Bus Configuration and Bus Load in a Tractor Fertilizer Spreader System

(LBS by DIN 9684)

by

H. Auernhammer, M. Demmel
Institut für Landtechnik
Technische Universität München
Freising-Weihenstephan, Germany

R. Ostermeier
GEO-TEC electronics GmbH
Hallbergmoos, Germany

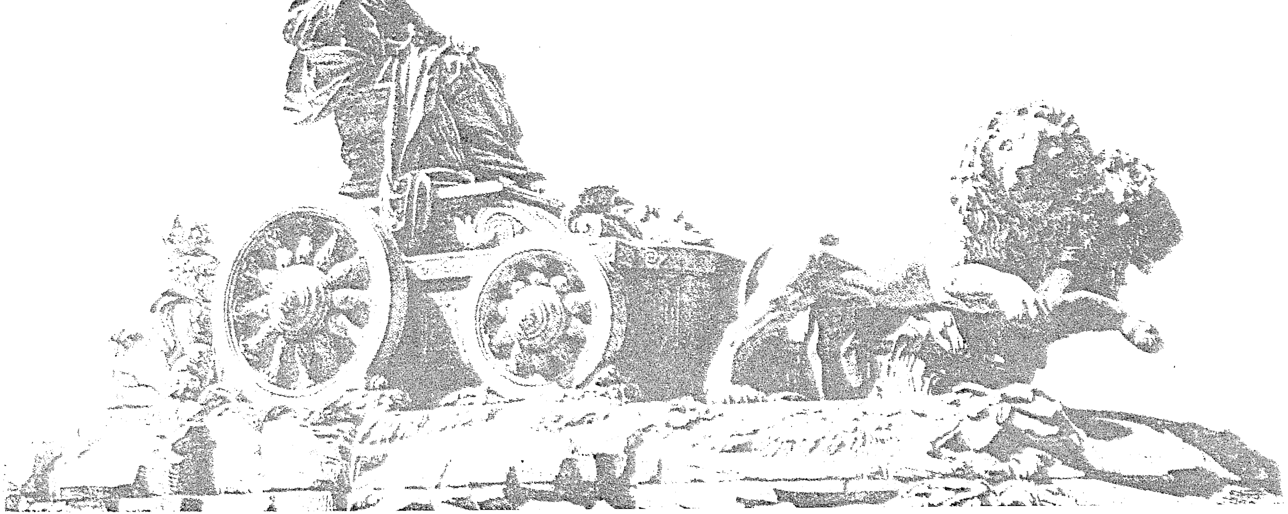
R. Weigel
Lehrstuhl für Hochfrequenztechnik
Technischen Universität München, Germany

SUMMARY

The busload in a standardized tractor implement communication system (LBS) was investigated. The system consists of a tractor with internal bus, a communication gateway to the tractor implement bus, bus terminal, task controller and one electronical controll unit in a fertilizer spreader. Busload without spreading activity was about 12%. Homogeneous treatment increased the busload to about 19%. Higher busload with about 27 % occured during system initialisation. The transfer of positioning data from GPS on the bus encreased the busload about 1% by an update rate of 1s respectively 4% by an update rate of 0.2 s. The system showed a fairly good reliability.

KEYWORDS:

Electronics, tractor, data-transfer, bus-system, LBS, busload, GPS, positioning



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Introduction

In today´s agriculture, economic and ecological optimization of production and working processes is an important objective. Thus, electronics is increasingly becoming an integral part of modern tractors and the equipment they drive. The "Landwirtschaftliches BUS-System (LBS)" or "Agricultural BUS-System" [1, 2, 3, 4, 5, 6, 11,15], described in DIN 9684 Parts 2-5 [9] establishes a general standard for the communication of electronic controllers in a tractor implement combination using the "Controller Area Network (CAN)" [8]. In 1993 first prototypes with LBS where established and presented at the AGRITECHNICA at Hannover [7]. Since this occasion further additions and improvements as well as adaptions to the working drafts of ISO 11783 [12] where included in the final working draft of the standard and will be published before the end of this year. Meanwhile several manufacturers have announced the initial introduction of serial LBS products and first demonstrations to farmers took place during the last two month.

Objectives

As early as April 1995, a LBS System for site specific spreading of fertilizer was implemented and available for specific investigations at the Institute for Agricultural Engineering at the Technical University of Munich-Weihenstephan. Systems components included a LBS-compatible tractor with an own CAN-based communication system, a mineral fertilizer spreader with an electronical control unit (ECU) and a LBS terminal with an integrated task controller (fig. 1), i.e. quite a realistic combination of systems for future applications of LBS.

Dr. H. Auernhammer, Associate Professor and Group Leader "Work Science and Process Control", M. Demmel, Scientist, Institut für Landtechnik at the Technische Universität München, Vöttingerstr. 36, 85350 Freising, Germany,
R. Ostermeier, GEO TEC electronics GmbH, Am Söldnermoos 17, 85399 Hallbergmoos, Germany and
Dr. R. Weigel, Associate Professor, Lehrstuhl für Hochfrequenztechnik at the Technische Universität München, Arcisstr. 21, 80333 München, Germany

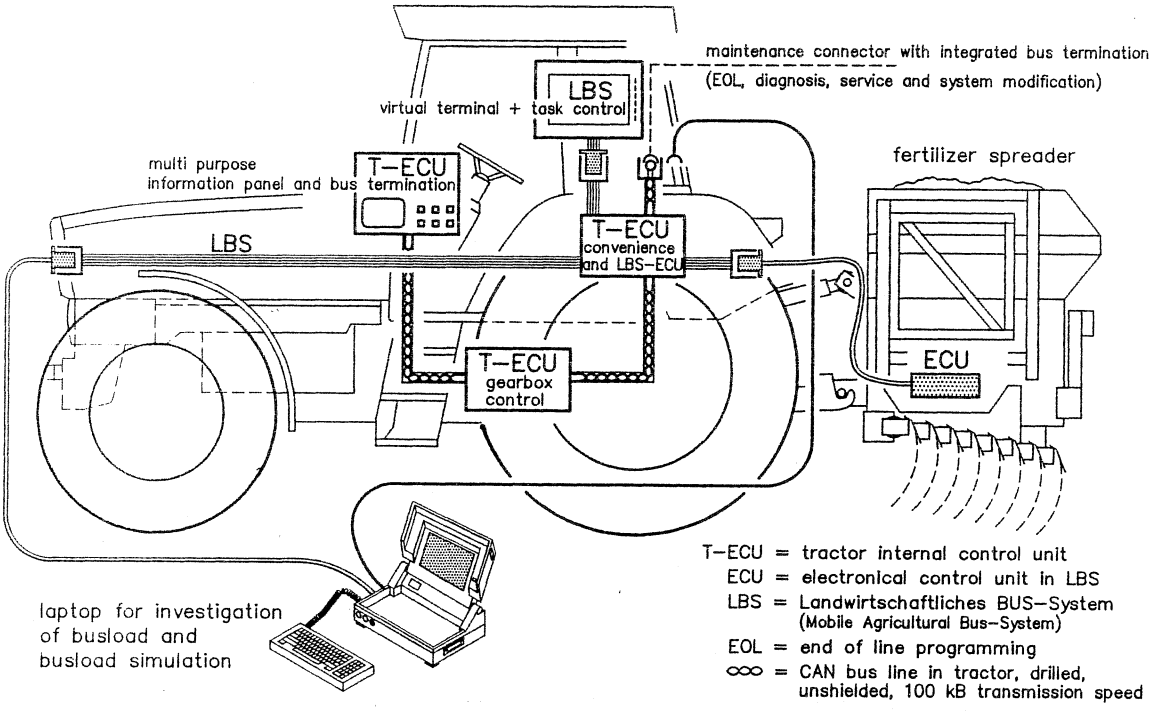

Fig. 1: LBS in a test configuration for investigation of bus load and bus load simulation

After minor problems in cabling during the combination of the components from different companies together with the needed analyser the system was ready for two groups of tests.

1) With respect to data transmission, LBS is based on the fieldbus CAN, a low speed controller area network. This means that electronic control units in a multi master environment communicate via a common physical data transfer medium. The efficiency of the total system therefore dependends on the transfer capacity and vulnerability to interference of the underlying communciation system. Therefore controlled busload analyses at various stages of operation were carried out to reveal actual bus load within the fertilizing system at hand. In this, both total and partial loads resulting from individual LBS data groups were of interest.

2) Spatially-variable crop production promises an economical, environmentally sound future option for an optimization of processes in agriculture [14]. For this, reliable location sensing is required. Standardized integration of a positioning method into LBS is therefore an obvious choice. The experiment endeavoured to answer the following questions: Which concepts do exist, which additional bus charges do they entail, what are the limits with respect to exact positioning depending on location sensing, update rate and the influence of data transfer? As far as data transfer is concerned, the answers to these questions are closely connected to the second most important criterion for the performance of a field bus system - i.e. its real time performance which determines the kind of delays in data transfer

To find the required answers to this questions the investigations were planned and carried out in two steps:

First of all the system should be tested for its overall performance as well as the operative capacity of the communication system LBS is based on. This tests should be undertaken at the real system with farm specific setpoints for fertilizer spreading.

Then investigation should also consider possibilities for the integration of a location sensing system, e.g. satellite positioning with GPS and/or DGPS. This investigations should be done simulating the transfer of positioning data with different update rates.

Methods and Material

Bus load and transfer delay times: Tasks such as busload analyses or the determination of transfer delay or reaction times in data networks are problems typically dealt with by means of network analysis. A general explanation may be found in GERDSEN and KRÖGER 1994 [10], its interpretation for LBS in OSTERMEYER 1995 [13].

The busload in question for the "LBS-CAN-Bus" may be calculated according to formula (1).

$$Busload = \frac{transferred\ bits\ per\ analysed\ interval}{maximal\ number\ of\ bits\ per\ analysed\ interval} \times 100\ \%$$

with

$$maximal\ number\ of\ bits\ per\ analysed\ interval = \frac{transfer\ rate}{analysed\ period}$$

Data transfer delay times are determined by the time required for the faultless transfer of a CAN data frame as well as the interval between transfer request and successful bus arbitration. Thus, a dependence on respective busload is evident. Since CAN involves a prioritized bus arbitration process, the variable priority of a message plays a decisive role.

Integration of a Positioning Method: There are two opposite options for an integration of positioning into LBS, centralized or decentralized positioning respectively. Combinations of the two concepts are also imaginable. A centralized option means that positioning and job processing data are dealt with in an electronic processor unit and positioning data is not transmitted directly to the bus. Decentralized positioning, on the other hand, involves one or more positioning processors continually transferring positioning data to the bus. Actual job processing may be divided. Since positioning data is considered process data, it is defined as basic data or as having lower priority than LBS data. Due to the continual movement involved, potential precision of the technical device for spatially-variable crop production not only depends on the quality of the positioning data, but also on update rate, reaction times of local control and devices as well as potential data transfer delay times of LBS-(process) data. In a dynamic system such as LBS, transfer delay times cannot be seen as purely deterministic. In the "best case", they would include only telegram transfer times, the description of a "worst case scenario" makes sense only after possible interferences have been thoroughly investigated. If security-related aspects do not play a prevalent role, useful comparative values for the actual range of delay times of LBS-process data can be derived from measurements in a real system. Results are applicable to comparable systems configurations and process conditions.

Concept for actual measurements: With respect to busload and transfer delay times, decentralized positioning is the upper limit for all integrational variants. Measurements for this case therefore also apply to other variants.

LBS-System Employ, Measurement Techniques and Data Analysis: The LBS-system employed consisted of a tractor (FENDT Favorit 511C with 85kW) with a tractor LBS gateway and a bus system according to DIN 9684 Part 2 (data transfer rate 50 kBit/s). A partial range fertilizer spreader (RAUCH AERO 2115) with a working width of 15 m and an LBS fertilizer spreader control unit (LH AGRO) were attached. Task controlling was integrated into the LBS-terminal (LH Agro AGRO CONTROL TERMINAL).

The technical testing involved a robust industrial PC (KONTRON IP-Lite PC486) with an installed programmable CAN analysis tool (VECTOR INFORMATIK "CANalyzer Pro"). Additional hardware and software allowed passive online measurements, i.e. bus traffic was merely observed and recorded for later offline analyses. Active online testing was also possible, however, allowing online simulations and analyses as an independent LBS participant. This became necessary since spatial variable operation was as yet not sufficiently stable. Homogenous operation (repeated transfer of desired or actual values) and decentralized positioning, consisting of a "package" of four process data telegrams (X, Y, Z co-ordinates, quality information) respectively, were simulated and investigated in this way. Positioning update rates of 1 Hz to 4 Hz (cf. available GPS-Systems) were used.

Specially implemented offline analyses programs, one for selective busload analysis and one for investigating data transfer delay times dependent on selective busload, processed all obtained online data and recorded results in an ASCII file. Graphical representations of the results were generated using a commercial graphics program.

Results

Installation of the system hardly posed any problems. Difficulties arose, however, from an incomplete definition of the so-called "LBS physical layer" as well as incompatible software versions of the emplement ECU's, since individual implementations were based on different standard working drafts. Both problems could be solved in co-operation with the manufacturers.

Figure 2 shows the development of total busload (duration of analysis period: 2 seconds, resolution 0.12%) for a systems operation of 30 minutes. Since constant operating conditions were used for all stages, it was in this case possible to assign partial load directly to respective cause without looking at selective busload graphs. The small range within individual stages and the gradual load change whenever alterations in operating conditions occurred are remarkable.

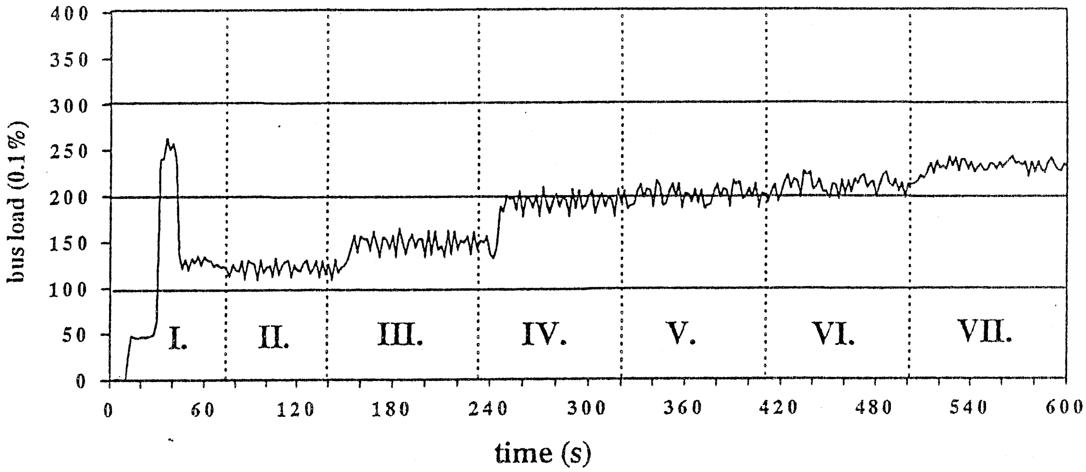

Figure 1: Busload of an LBS tractor fertilizer spreader system

The highest busload value of 26% was reached at initialization (I.) and caused by the transfer of the "terminal display" for the spreader. The standards requirement, that a mean busload of about 40% may not be exceeded, could therefore be met. After initialization, busload decreases to 12% for the stationary mode (II.), which is characterized solely by the transfer of systems alife data, basic data #1 and #2, calendar dates and "tractor terminal messages". Activation of the working menu for the fertilizer spreader (III.) results in a load increase of 3 percent. Start of the homogenous process operation (IV.) leads to another increase of 4.5%. Altogether, this amounts to a total load of 19.5%.

Decentralized positioning once again increases the load, with an increase of the update rate resulting in a rise in busload. Periodical transfers of positioning packages with 1 Hz (V.) causes an additional load of 1%. A double update rate of 2 Hz (VI.) results in a 2% increase, a rate of 4 Hz (VII.) in a plus of 4%.

Data transfer delay for "positioning packages" remains constant and almost independent of the update rate for the existing busload situation. The mean for the four telegrams lies at 11-12 ms, at its highest 22-24 ms, i.e only 1/40 of the duration of the positioning period of one second (1 Hz). Parallel measurements of transfer delays for other process data clearly indicate that no noticeable detractions are to be expected through decentralized positioning with such an LBS systems configuration and its resulting busload.

Conclusions:

Taking all results into account, the following conclusions can be drawn:

The tested system showed a fairly good reliability. Problems and break downs arose seldom in a random matter. They where mainly caused by the used LBS-Terminal and/or by the implement ECU. There was no break down in combination with the tractor ECU.

The average busload in a stationary situation (out of work) is about 12%. Activation of implement monitoring increases the bus load by about 3% and homogeneous treatment with the fertilizer spreader causes an additional increase of the busload by another 4%. Therefore it can be expected, that a transmission speed of 50 kB can fulfill the data transfer requests of a LBS system consisting of a tractor, a LBS-terminal, a task controller and 3 to 4 implement ECU's.

System initialisation causes a high busload and a incalculable time delay in the use of the system. It might be a good practice to extend the proposed standard with the ability to import the needed masks form the ECU's once and store it permanent in the LBS terminal or to import them by chipcard or another media.

Decentralized positioning with an update rate of 1-2 Hz ensures a potential precision of 1 m (operating speed < 5 m/s) without seriously interfering with the capacity of the communication system in an LBS System of the described configuration. The new standardization (1996) postulating a 125 kBit/s transfer rate instead of 50 kBit/s, will noticeably improve the situation once more. For precision requirements below 1 m, centralized positioning is recommended.

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