ACQUISITION AND PROCESSING SYSTEM INFORMATION MOTION WHEELS OF THE VEHICLES THAT ARE MOVING ON THE SPECIFIC CONSTRUCTION SITES

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Abstract: *The presented acquisition system has in its structure: five speed transducers, an interface with the computer and data acquisition software. The speed transducer is a simple thing to do from the mechanical and electronic point of view, in operation being very accurate, reliable and robust. The graphic interface of the data acquisition software uses the parallel port of a personal computer with Windows XP operation system. The well functioning of the interface is based on the computer's internal clock, in the registries of the parallel portal being memorized the time at which a state change occurred on the respective portal. These times are saved in a text folder which is later processed with Pascal programming languages or specialized software like MathLab. With the movement under difficult operating, with major wheels slip, through mud and see waters, large obstacles which lead to great debates of the four wheels of the motor vehicle, the presented system was totally satisfactory.*

Keywords: wheels, experimental, speed transducers, interface, software, construction sites.

1. IMPOSED CONDITIONS FOR THE SPEED TRANSDUCER

Interaction between the tire and the running track is based on the measurement of the reaction from the wheels of the vehicle for different schemes and handling charges and on the measurement of the slipping wheels and the transverse deflection angle. In all the above cases an important size that must be measured is the wheel speed.

In [1] is presented an experimental installation that allows us to measure in driving conditions the longitudinal strength and transverse forces. The installation contains, among others, a device with "the fifth wheel" that allows the determination of the speed of the vehicle. Next, we will present a device made by the authors, used in the measurement of the speed, in difficult running conditions for the vehicle. In difficult operating regimes of the vehicles, like the ones from a construction yard, in order to measure the wheels' speed and the speed of a vehicle we have the following problems:

- because of the bumps and the alternating mud areas with the dried ones, we can not use a device with "the fifth wheel";
- passing through a see water and the total or the partial covering with water impose an isolation of the speed traducers attached to the wheels from the electric point of view. The used transducer will be protected against the sand so it can not be blocked.

In respect with the previous affirmations, we projected a measurement device for the speed of the four wheels and for the output speed of the gearbox.

We preferred to place the speed transducers on the inside of the vehicle, the transmission of the speed being realized with a protected cable, like the tachometer cable.

The transducer itself is an optical speed optical transducer, at one revolution being obtained 36 pulses.

In [1] it is imposed the minimum value of the constancy of the pulse transducer equal with 15 pulses/revolution.

2. THE DESCRIPTION OF THE SPEED TRANSDUCER

The projected speed transducer was mounted on the four wheels of the ARO vehicle and has in its composition:

- mounting hub device;
- tachometer cable;
- driving device of the optical transducer;
- optical transducer.

The location and clamping on the front and back wheels of the vehicle are presented in figure 1.

Fig. 1. Method of installation of the speed transducers.

The movement of the wheels is transmitted through a flexible cable to an optical transducer. This generates at a revolution of the vehicle's wheel 36 pulses after the principle from figure 2.

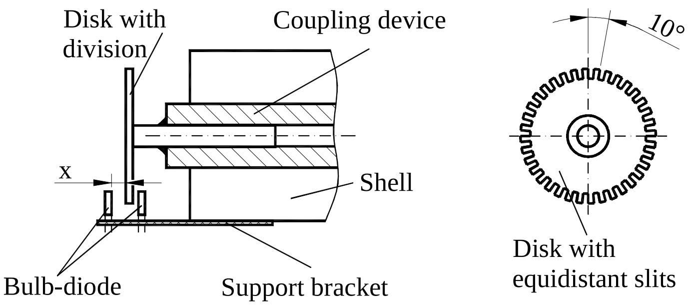

Fig. 2. Principle of operation of the optical transducer.

In figure 3 are presented two views of the optical transducer and of the training device. The optical device uses computer CD-s.

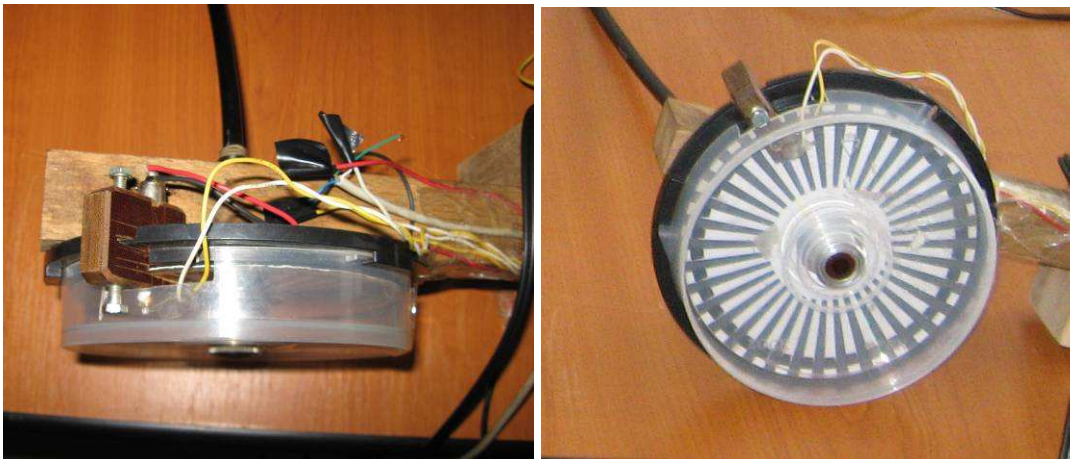

Fig. 3. Optical transducer.

Constructive, the optical transducer uses two transparent disks and a disk with divisions marked on a printer specialized in printing the CD-s. The aspect of the disk which is about to be written is given in figure 4. It is projected in AutoCAD, being well-known the accuracy of calculation and drawing of this soft used in assisted projecting.

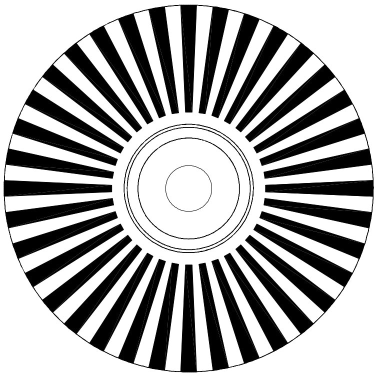

Fig. 4. Divisions of the transducer disk.

The optical transducer runs on pulsed light generated by the disk with slits from figure 5 and red by the diode (fig. 2).
This way it is generated a train of pulses, which are next processed by an interface with the computer.
In figure 5 it is presented the electrical diagram of a processing mode of the pulses generated by the optical transducer and the adaptation with parallel port of the computer.
To avoid the accidental damage of the parallel port from the computer it was introduced an optocoupler.
On a vehicle, the energetic sources frequently generate electrical impulses considered to be parasite because they generally overcome the usual work tensions of a parallel port. By using the optocoupler we avoid the parasite pulses that not belong to the speed transducer and to damage the port of the PC.
The interface is composed of three modules:

- modulus of powering 5V,
- modulus of training impulses,
- modulus of electrical isolation.

The powering modulus reduces a 12 V tension of the vehicle to a 5V tension needed to power the training impulses modulus. It is used a specialized integrated (806) and a classical protection and filtering circuit made of diode, coil and capacitor.
Training impulses modulus uses a specialized integrated NE 555. This integrated realizes at the output rectangular pulses with 50% filling and 5V amplitude. We need this modulus because the optical transducer does not generate rectangular pulses, the shape of the pulses being dependent of the revolutions. At low speeds the pulses generated by the optical transducer are highly distorted (smooth

slopes), the modulus being responsible not only by the perfect rectangular shape but also by the optimum operating voltage of optical coupling.

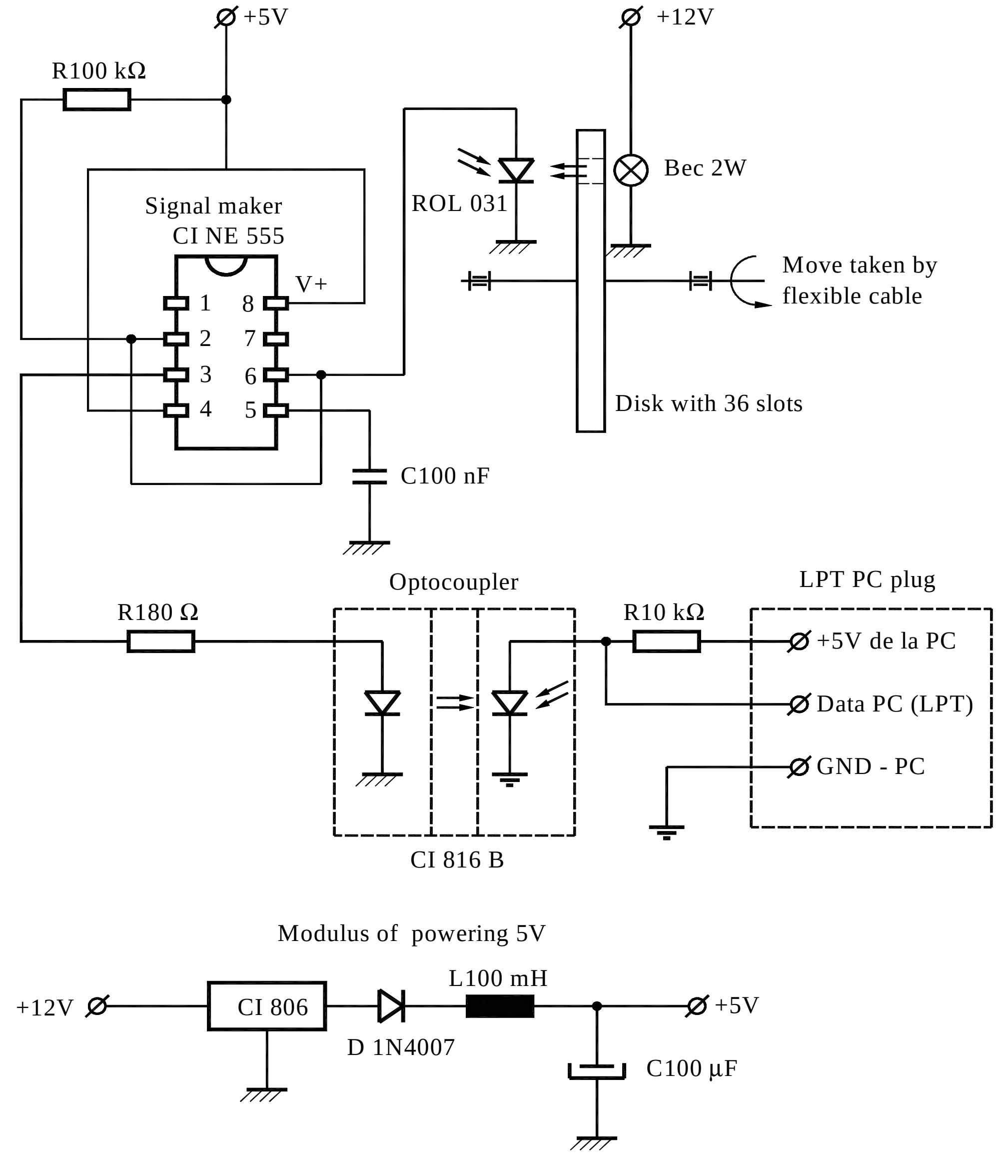

Fig. 5. The interface with the computer.

The third modulus, of electrical isolation, has in its structure a specialized integrated circuit type 816 B (optocoupler). Together with the adjusting of the load resistors the information is transmitted to the computer without direct electrical coupling.

Because of the measurements taken on the route, in terms of site, when we used a portable computer, we preferred to use 4,5 V battery to power the optocoupler. We realized in this way a supplementary protection of the parallel port in case of an accidental short-circuiting of the 5V tension from the PC.

Figure 5 presents the interface and the optical transducer. From electrical point of view, the optical transducer is made of a auto bulb of 12 V (power 2W) and the diode ROL 031.

In figure 6 it is presented the interface with the computer for all the five modules that take and process the signals from the four wheels of the vehicle and from the gearbox.

The system of the four speed transducers (optical transducer, flexible cable and wheel clamping flange) is presented in figure 7. These transducers are standardized in a laboratory by the help of a standard signal generator, oscilloscope and frequencymeter.

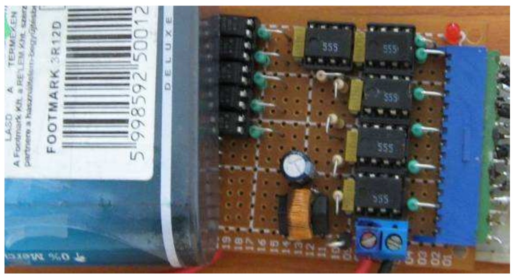

Fig. 6. The interface-PC system.

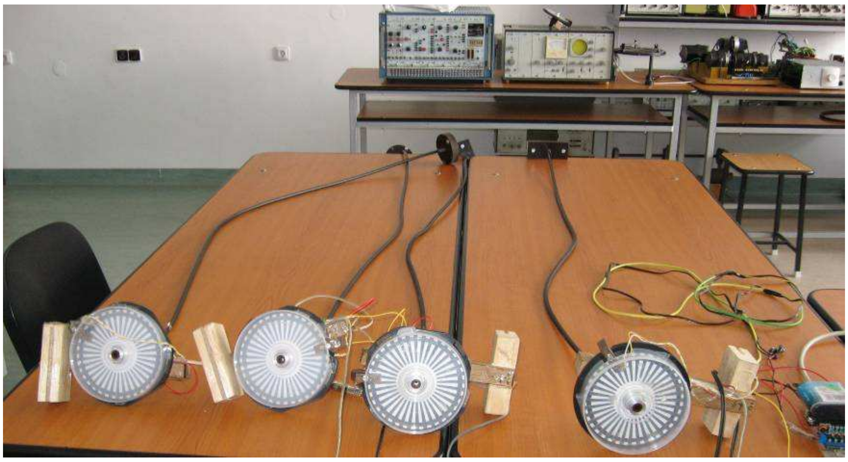

Fig. 7. Speed measurement transducers assembled and ready for calibration.

3. DESCRIPTION OF SOFTWARE FOR DATA ACQUISITION

The big amount of information taken in a very short period of time leads us to the need of designing a software in own machine code that offers us in real time information about the purchased sizes.
First of all we have used a webDAQ/100 data acquisition board which based on its own soft, stores in its memory the acquired data. After finishing the data's determination, they are saved on laptop, in order to be processed through some programs in Pascal language.
Starting from the deficiencies found in the experimental determinations, the necessity of projecting of an interface specialized in processing data on a high frequency, on five entries and on a larger time frame was revealed.
Thus the interface presented in fig. 8.18 has resulted. For this interface we have created a soft written into machine code. The functioning way of the interface from figure 5 is absolutely different from the functioning of the webDAQ/100 data acquisition board. This board functions on the principle of sampling the entry signal. In case of using several channels of entry a multiplexing of the acquired data is being done, which introduces a desynchronization between the entry signals.
Even if the sampling frequency is higher, a phase error appears on the acquisition and then on its' processing. The errors further obtained through the numerical processing of the data increase leading to high dephasing between the channels.
By the use of the projected interface this disadvantage is eliminated. This doesn't work on the principle of the sampling, marking the time of an event and writing it in the registers of the parallel port. Thus the signals can be synchronized, the accuracy of the determinations depending only of the trainer pulse.
The measurement channels are independent and no longer depend on the multiplexing frequency.
Another great advantage is the rapid transfer of the data directly in the numerical computer, a further processing of the data being unnecessary. This processing of the data in the case of the webDAQ/100 data acquisition board and their saving on the computer took, for five signals and duration of one minute of their determination, approximately 15 minutes.
In the case of a new interface (fig. 5) and benefiting from the written soft in machine code the saving of the data is done in real time. Another huge advantage is connected with the volume of the acquired data. Practically with the new interface and the right soft we can acquire data up to the limit of the hard-drive of the computer we use (thousands of hours of acquisition on five channels).
The webDAQ/100 data acquisition board was limited at its internal memory, for a couple of minutes in the case of the volume of data acquired on five channels, after which it was necessary to download the data from the computer's memory, which took lots of time.
In figure 8 we have presented the graphic interface of the data acquisition soft using the parallel port of the computer and the Windows XP operating system.

Fig. 8. The graphic interface of the data acquisition soft.

The graphic interface allows the real time visualizing of the used traducers. It has been projected for the simultaneous data acquirement on eight channels (byte). The stated advantages are obtained first of all thanks to the way of working with digital signals.

The functioning of interface is based on the internal clock of the computer, in the registers of the parallel port the time of a state change being memorized on the respective port (a passing from 0 in 5V or the other way around). These times are saved in a text file which is then processed with programs made in Pascal programming language or in well-known software like Math Lab. To acquire the data we proceed like this:

- we connect the interface to the parallel port and we power the transducers with 12 V, the interface with 5V and the eventual circuit of the optocoupler with a battery of 4,5V,
- we run the data acquisition executable file, and the window from figure 8.22 appears,
- we monitor the functioning of the data acquisition channels (optical transducer, signal maker, optocoupler) symbolized by the intermittent lightening of the eight symbols that imitate the light bulbs, from the graphic interface,
- the file where the data will be saved is named,
- we start the data acquisition when the mechanical system is ready by pressing the start icon,
- we stop the data acquisition at the end of the attempt, the data being located in the previously named file.

File Edit Format View Help

Nr_Crt	D4	D3	D2	D1	D0	Data	Ora	Diferenta
1	1	1	1	0	1	11/12/2007	15:2:21:743	0
2	1	1	1	0	0	11/12/2007	15:2:22:655	891
3	1	1	1	0	1	11/12/2007	15:2:22:685	921
4	1	1	1	0	0	11/12/2007	15:2:22:695	931
5	1	1	1	0	1	11/12/2007	15:2:22:725	961
6	1	1	1	0	0	11/12/2007	15:2:22:735	971
7	1	1	1	0	1	11/12/2007	15:2:22:775	1011
8	1	1	1	0	0	11/12/2007	15:2:22:785	1021
9	1	1	1	0	1	11/12/2007	15:2:22:825	1062
10	1	1	1	0	0	11/12/2007	15:2:22:835	1072
11	1	1	1	0	1	11/12/2007	15:2:22:855	1092
12	1	1	1	0	0	11/12/2007	15:2:22:865	1102
13	1	1	1	0	1	11/12/2007	15:2:22:885	1122
14	1	1	1	0	0	11/12/2007	15:2:22:895	1132
15	1	1	1	0	1	11/12/2007	15:2:22:925	1162
16	1	1	1	0	0	11/12/2007	15:2:22:935	1172
17	1	1	1	0	1	11/12/2007	15:2:22:985	1222
18	1	1	1	0	0	11/12/2007	15:2:22:995	1232
19	1	1	1	0	1	11/12/2007	15:2:23:25	1262
20	1	1	1	0	0	11/12/2007	15:2:23:35	1272
21	1	1	1	0	1	11/12/2007	15:2:23:105	1342
22	1	1	1	0	0	11/12/2007	15:2:23:125	1362
23	1	1	1	0	1	11/12/2007	15:2:23:215	1452
24	1	1	1	0	0	11/12/2007	15:2:23:225	1462
25	1	1	1	0	1	11/12/2007	15:2:23:306	1542
26	1	1	1	0	0	11/12/2007	15:2:23:316	1552
27	1	1	1	0	1	11/12/2007	15:2:23:336	1572
28	1	1	1	0	0	11/12/2007	15:2:23:346	1582
29	1	1	1	0	1	11/12/2007	15:2:23:466	1702
30	1	1	1	0	0	11/12/2007	15:2:23:476	1712
31	1	1	1	0	1	11/12/2007	15:2:23:486	1722
32	1	1	1	0	0	11/12/2007	15:2:23:496	1732
33	1	1	1	0	1	11/12/2007	15:2:23:676	1913
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36	1	1	1	0	0	11/12/2007	15:2:23:766	2003
37	1	1	1	0	1	11/12/2007	15:2:23:826	2063
38	1	1	1	0	0	11/12/2007	15:2:23:836	2073
39	1	1	1	0	1	11/12/2007	15:2:24:7	2243
40	1	1	1	0	0	11/12/2007	15:2:24:17	2253
41	1	1	1	0	1	11/12/2007	15:2:24:67	2303

Fig. 9. Text file resulted from the acquisition.

This interface has the advantage of visualizing of the data acquisition for each and every channel (in real time). The shape of the file is the one in figure 9.

4. THE ADJUSTMENT OF THE REVOLUTION TRANSLATOR

First we have monitored the shape of the impulses generated by the revolution translators. For a high precision of the acquired signals the impulses must be rectangular and with a fill factor of 50%. This aspect has been observed from the projecting phase of the transducer's disc (fig. 4), the opaque sectors (black) being equal in angle terms with the transparent sectors (white). Another source which influences the fill factor is the light source that must be point light or light guide. We have solved this aspect by the use of a tube which guides the light wave. The positioning of the optoelectronic receiver can be another source of influence of the fill factor.

The optoelectronic receiver must be as small as possible, maximum the thickness of a slot, and it must be mounted axially with the light source. These last aspects have been solved by projecting of an overall bulb-photodiode, which meets all the previous requirements. Electronically, the adjustment of the speed transducer assumes:

- checking of the correctness of the mechanical assembly,
- checking of the deviation of eccentricity and of coaxiality of the assembled transducer disk,
- checking of the correctness of the electric links,
- checking of the supply voltage and its coupling to the transducer,
- checking of the operation bulbs,
- training disc slots and viewing the oscilloscope of the signal's form generated measured on the 3rd pin of the 555 integrated; the correct form of the signal is the one from figure 10,
- in case that the signal doesn't have the right fill factor the distance between the source of light and the optical disk is adjusted,

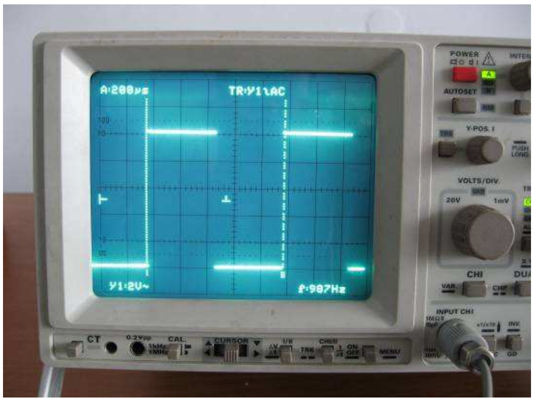

Fig. 10. The shape of the signal generated by the transducer.

5. CHAIN SIZING MEASUREMENT

Chain sizing measurement and data acquisition composed of the transducer, the interface and the computer assumes the browsing of two main steps. The first step is the chain sizing measurement in the lab by taking the following steps:

- development of mechanical connections between the flanges, flexible mechanical cable and disk slots,
- achieving electrical connection between the interface and the parallel port of the PC,
- powering interface tension (5 Vcc) and of the optic coupler 816 B (4,5 Vcc),
- connecting of a generator of rectangular signal at the entry of the interface (6th pin of 555 integrate),
- tracking of the signal with the oscilloscope both on the 3rd pin of the 555 integrate and at the exit from the optical coupler 816 B; at both measurement points the signals must be rectangular and they must have the fill factor of 50%,
- we start the PC and we load the acquisition soft,
- we adjust the generator on fixed frequencies: 10 Hz, 50 Hz, 100 Hz, 200 Hz and 250 Hz; it has been estimated that the data acquisition will not overcome the 200Hz frequency, which certifies the correctness of the acquired data,
- for the five data acquisition channels we want individually that the acquired signal to have the right corresponding period for the frequency of the generator, the time of the acquisition to be correct (the interface memorizes times, so, the difference between the first and the last signal will determine the duration of the acquisition),
- through a resistive divisor we introduce the signal form the generator at the five entries of the interface; as in the previous case we want the acquired signal to have the right period and that the time of acquisition to be correct; this supposes the viewing of the data from the text file and the performing of basic mathematical calculations of transforming the time frequencies, to follow the data correctness (the sequences 0 - 1 and the time displayed and computed as in figure 9).

The second stage is the chain sizing measurement in the field by taking the following steps:

- choosing of a straight path with minimum length of 100 m, that can be followed both ways at a constant speed; the tread will be of good quality, aiming at factual accuracy of the acquisition signal on the car in normal running conditions (without sliding, skating, acceleration or braking),
- checking the tire pressure according to the manufacturer's indications,
- the measurement of the dynamic range of car tires by: landmark designation of tires and asphalt, pushing the car until it takes up to five full rotations for each tire and finally measuring the distances traveled,
- temperatures reaching scheme for car, tires and data acquisition equipment,
- the four mounting flanges on the wheels of the car and the transducer coupling fifth out of gear,
- achieving electrical connection, the connection of power to optical transducers and to the interface, the start of the laptop and the loading data acquisition software, data acquisition 40 km/h speed is constant between the landmarks that define the distance of 100 m, assisted by a GPS, in both directions is performed at least three determinations in each direction of travel.

The checking of the accuracy of data acquisition is done by is aiming at the calculated distance traveled is equal to the covered and that the angular speeds of the wheels are equal and constant (zero angular acceleration).

6. CONCLUSIONS

The measurement experiments were performed inside a ballast. Chain measuring transducers and gave full satisfaction measured by these conditions.
For a thorough analysis of the angular velocity a numerical integration on an interval equal in length to place the wheel has been made, thereby eliminating parasitic values resulted from numerical differentiation and imperfections in the transducer.
Also it is necessary for the route to be traveled in both directions several times, so that values obtained from determinations to be closer to the reality, even if it is difficult to maintain the same conditions in the determinations.
In a ballast route parameters may change daily according to operating conditions, directly influencing the conditions of vehicles crossing, the time of covering the routes, speed and fuel consumption. It was noted that the same route is an optimal effect scroll.
Speed transducers must be robust, protected against water penetration, mud and very fine particles of sand penetration that may lead to their blocking or to errors in functioning.
In figure 11 are shown two pictures with the right front wheel transducer before and after the experimental determinations of site. Is observed after the appearance of wheel and body of the vehicle the rough conditions in which the transducer has worked in, in some parts of the route is almost covered by water and mud.
The protection of the mechanical transducer as well as the way of the location of transducer electronic speed (inside the vehicle) has allowed the proper functioning of the whole data acquisition.

a) ***b)***

Fig. 11. The transducers before and after the measurements.

From the experience gained by trying different types of interfaces we have found that in such cases it is not recommended to use the interfaces which sample the entry signal, but those interfaces that include data pulses transducers.
Theoretically angular speed gearbox read is always between the angular velocity curves of the left and right wheels. In reality due to sliding there are portions of graphic that show that this rule doesn't apply.
The making and interpreting the results of experimental research, have led to obtain important data on the values of specific parameters stability, on difficult routes or to addressing obstacles in dry land conditions, wet and covered with sand which can be considered as start dates for new studies to address stability and development to drive 4 x 4 vehicles and construction machinery.

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