High-Precision Distance Meter for Mobile Robotized Systems

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Abstract - **The developed mobile robotized system is presented. Necessity of high-precision distance measurements is proved. Distance error compensation methods are discussed. Mathematical models of the correctional amendments are developed. Results of estimation for measuring errors at modeling and prototype testing are presented.**

Keywords - **distance meter, amplitude fluctuations, signal distortion, error compensation methods.**

I. Introduction

Compact mobile robotized systems have found wide application in the industry and military areas [1]. Such systems are intended to receive remote multi-parametric information on investigated objects in zones which are dangerous to the person. Mobile robotized system is presented on fig. 1.

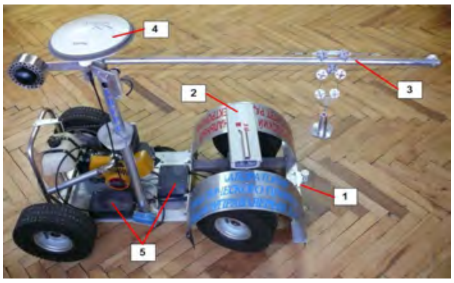

Fig.1 Mobile Robotized System

It consists from next parts:

1. Mobile multifunction platform
2. Distance Meter with CCD camera
3. Robotic Elevating Manipulator
4. GPS Receiver
5. Processing and Control Unit

Very important function of a mobile platform is safe autonomous movement in unknown terrain [2]. This task is made by a distance meter which provides the obstacle avoidance. Usually laser rangefinder is used as the distance meter. However strong amplitude fluctuations and nonlinear signal distortions lead to considerable measuring errors. Therefore an actual problem is development of error compensation methods to increase the measuring accuracy in such conditions.

II. Error Compensation Methods

Methods are based on correction of the received distance data by means of amendments. These amendments are formed on the basis of measurement of signal amplitude or duration in the amplifier saturation mode. The mathematical models have been developed taking into account piecewise-linear approximation.

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In case of amplitude fluctuations the amendments (Δt_{amp}) are estimated by Eq.1:

$$\Delta t_{amp} = \left[\frac{(\Delta t_2 - \Delta t_1)}{(U_2 - U_1)} \times (U_{\max} - U_1) \right] + \Delta t_1, \quad (1)$$

where Δt_1, Δt_2, U_1, U_2 - boundary values for chosen linear part; U_{max} – measuring signal amplitude.

Structure of the signal amplitude meter has been realized on the basis of the FPGA XILINX. For the pulse distortions amendments (Δt_{dis}) is calculated by Eq.2:

$$\Delta t_{dis} = \frac{(\Delta t_2 - \Delta t_1)}{(t_2 - t_1)} \times [T_0 (n_f - n_r) - t_1] + \Delta t_1, \quad (2)$$

where τ_1; τ_2 - boundary values of the chosen linear part; T_0 - the period of references pulses; n_f; n_r - number of the periods at TDC stopping by falling and rising edges.

Structure of the signal duration meter has been realized on the basis of the high-precision Time Digital Convertor (TDC-GP2 with resolution 50 ps).

On the basis of the developed methods the simulation model and Laser Distance Meter (LDM) prototype have been developed. Results of an estimation of measuring errors for modeling and field test are shown on Fig.2.

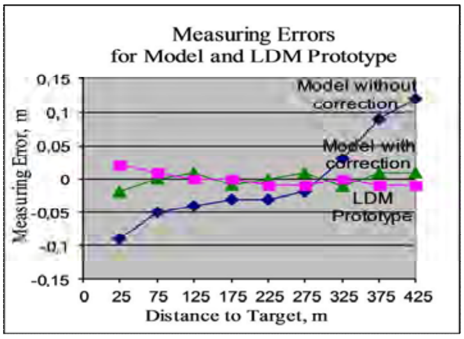

Fig.2 Measuring Errors for Test

The analysis of the received results has shown that distance measuring errors do not exceed ±1 cm for any changes of external conditions at use of dynamic error compensation methods.

III. Conclusion

The high-precision distance meter allows to realize effectively function of safe overcoming of obstacles on unknown terrain for a mobile robotized platforms.

References

[1] Everett H., Robotic Security Systems. IEEE Instruments and Measurements Magazine, Vol.6, No.4, pp.30-34, 2003.

[2] Lacroix S., et al., Autonomous Rover Navigation on Unknown Terrains: Functions and Integration. International Journal of Robotics Research, vol.21, No. 10 – 11, pp.917 – 942, 2002.