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SINGLE LATERAL CHANNEL AIDED INERTIAL NAVIGATION SYSTEM BASED ON NORTH CHANEL

VIENKANĀLA KORIĢĒJAMA SANU INERCIĀLA NAVIGĀCIJAS SISTĒMA AR ZIEMEĻU KANĀLU

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Keywords: inertial navigation, single-channel, lateral channel, North channel, aided, correction, accuracy analysis, error model, error propagation

***Abstract:** Inertial Navigation System (INS) block diagram analysis results show that it is possible to create single-channel Inertial Navigation System (1INS) using only one channel from conventional full-channel system - lateral, longitudinal or vertical channel respectively. In the full-channel variant of INS there is a crosslink between channels and for this reason the additional external flying vehicle flight parameter sources are needed for channel crosslink compensation. In the 1INS without these additional sources system error increases significantly in comparison with full-channel INS variant. 1INS lateral channel based on North channel model is offered in this work. Simulation results of this system error model are presented. Different variants of system correction using external velocity information source are offered (heading-aided 1INS). Different models of 1INS with correction are offered, and also error model with different correction variant and its combinations simulation results are presented in this work. Obtained simulation results shows that there is significant accuracy increase of 1INS when using offered correction methods.*

For successful operation of single- lateral channel Inertial Navigation System (1INS) it is needed latitude information to be available. There is no source of latitude information on the board of flying vehicle (excluding Global Navigation Satellite System). Latitude value is calculated in the North channel of Inertial Navigation System (INS). If the 1INS is based on North channel there is no problem where to get latitude information signal.

For the reason of absence of East channel in 1INS structure, which is based on North channel, the velocity signal U_E that represents crosslink between North and East channels can be obtained from kinematic equations in different coordinate

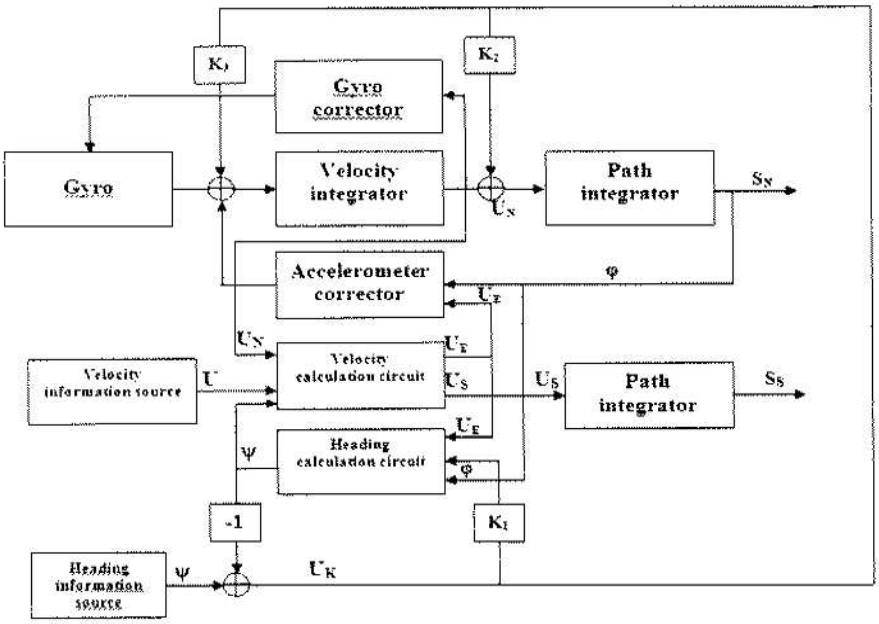

Fig. 1. Single-channel Inertial Navigation System based on North channel block diagram

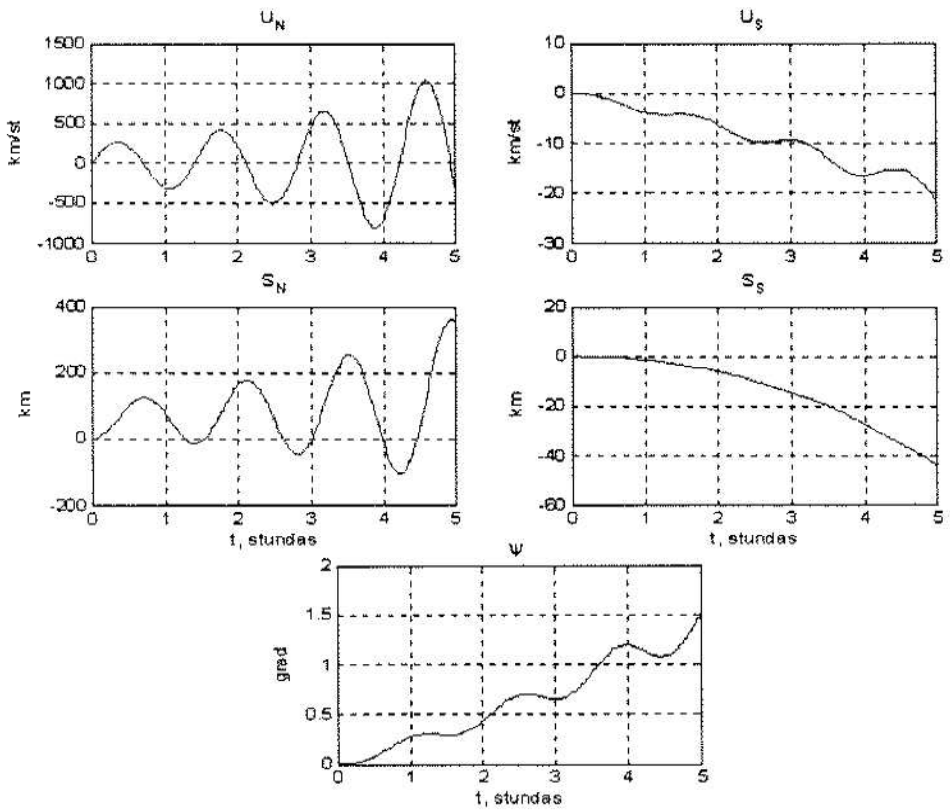

Fig. 2. 1INS based on North channel (without correction) error propagation with time

systems. Flying vehicle lateral velocity (U_η) in a great circle coordinate system can be found from kinematic equations too. As a result 1INS based on North channel structure complicates significantly. 1INS based on North channel block diagram is shown on Fig. 1.

Developed 1INS structure consists of INS North channel and three - heading, East and lateral velocity component calculation circuits. The error model was offered for developed 1INS. Error model simulations were performed with presence of all functional element error sources. Simulation results – system error propagation with time are shown on Fig. 2.

On Fig. 2. it is seen that developed 1INS system errors continuously increase with time Lateral position error ΔS_S rate of growth is 8 km/h.

Lateral velocity error ΔU_S growth rate is 4 km/h. It is seen that 1INS North channel error values are relatively high.

After 5 hour simulation time North channel position error ΔS_N reach 350 km and velocity error ΔU_N reach 1000 km/h (for comparison, convenient 1INS without correction velocity error reach 75 km/h and position error – 105 km). Developed 1INS based on North channel high error level can be described with additional circuit presence in 1INS structure. As a result there is closed loop with three integrators and this is the reason of high error level.

Special correction circuit is offered for system performance improvement, which operational principle is based on correction method which was developed in Aviation Institute of Riga Technical University.

There are poor correction possibilities of developed 1INS. There is only one variable available for correction – heading and for this reason the system can be corrected using only heading information source (Fig. 1.). Developed 1INS simulations were performed with variable correction circuit gain coefficient. Simulation results are error propagation with time curves.

For example on Fig. 3. are shown system error propagation with time curves when $K_I = 0.01$.

A result of artificial correction loop usage where heading correction is used is lateral.

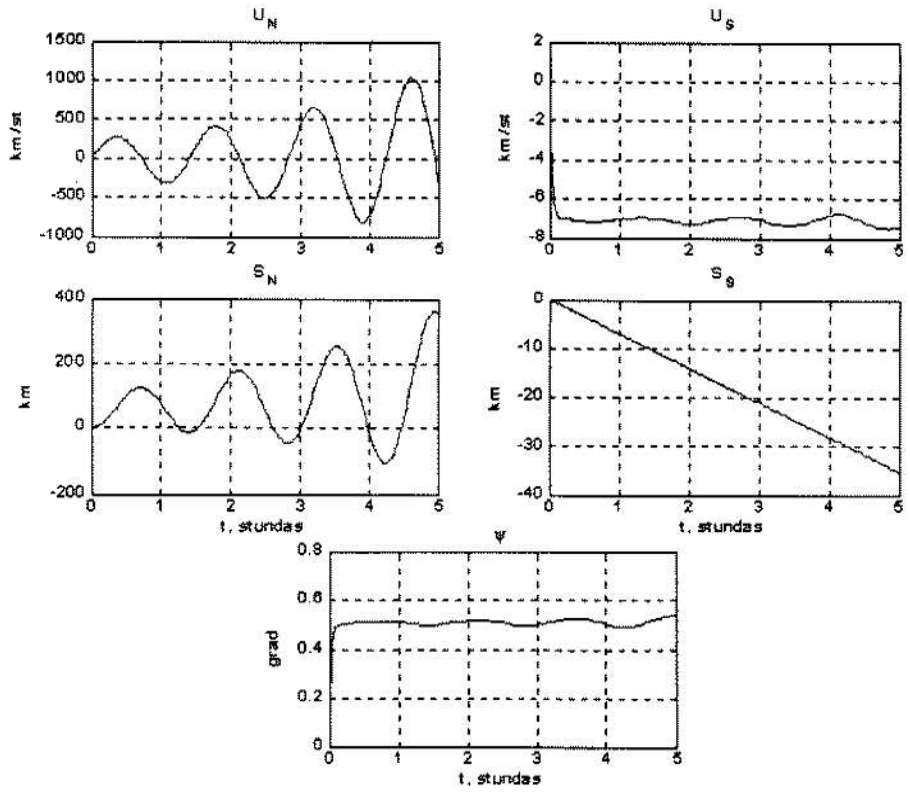

Fig. 3. 1INS with heading calculation circuit correction error propagation with time

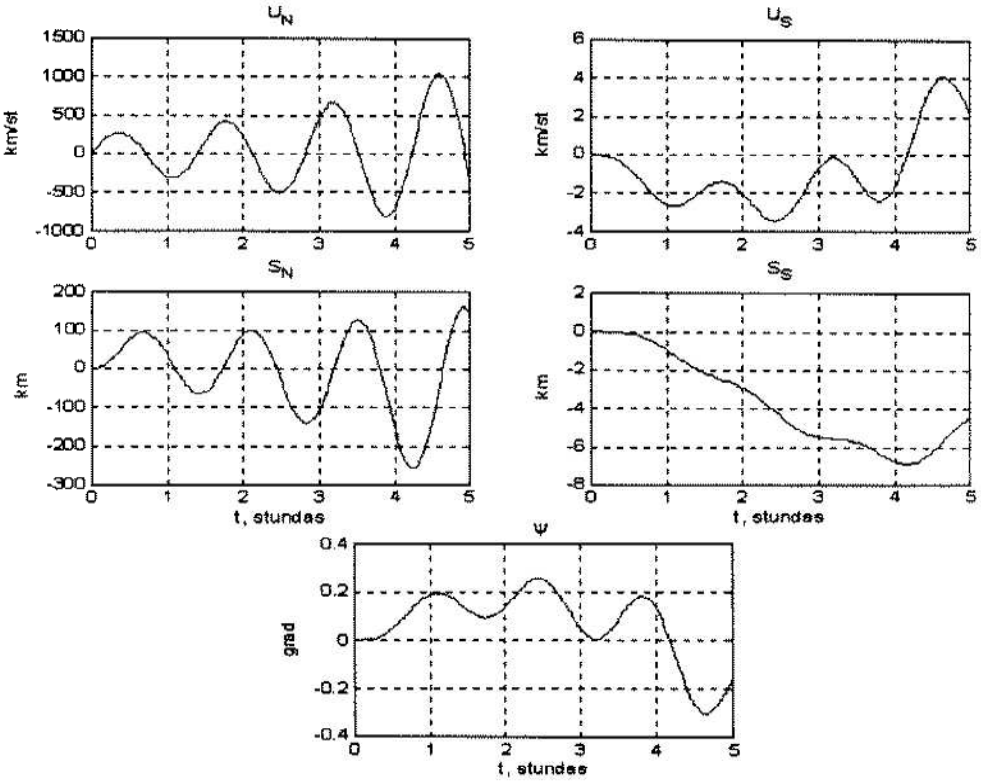

Fig. 4. 1INS with position integrator correction error propagation with time

channel velocity error $\Delta\Psi$ value stabilization at 0.5 deg level. There are no changes in North channel velocity and position error values in comparison with variant of system without correction. Correction loop variant in which only position integrator enclosed (Fig. 1.). Simulation results of this correction variant are shown on Fig. 4. when correction loop gain coefficient K_2 = 1500.

If correction loop encloses both integrators (resp. velocity and position) then lateral velocity ΔU_S and position ΔS_S error values significantly decreases in comparison with correction loop that enclose only position integrator

Lateral velocity value reaches 4 km/h after 5 hour simulation time and lateral position error reaches 7 km (1.7 km per hour) Heading error $\Delta\Psi$ increases in comparison with previous correction variant. North channel velocity ΔU_N and position ΔS_N position error propagation with time are without changes in comparison with variant without correction.

In this work correction variant were analyzed in which correction loop enclose fully North channel (Fig.1., K_3). In this case all errors increase with time (ΔU_S and ΔS_S are 12 km/h and 13 km respectively after 5 hour simulation time).

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P.Trifonovs –Bogdanovs, D.Fetisovs, T. Trifonova – Bogdanova. Vienkanāla koriģējama sanu inerciāla navigācijas sistēma ar ziemeļu kanālu

Inerciālā navigācijas sistēmās (INS)strukturshēmu analīzes rezultāti rada uz vienkanāla inerciālās navigācijas sistēmas (1INS) izveidošanas iespēju, izmantojot tikai vienu kanālu, attiecīgi - sānkanālu, garēnkanālu vai vertikālo kanālu. Pilnkanālā varianta sistēmai ir šķērssaites starp kanālu galvēniem ķēdēm, un tāpēc vienkanāla varianta gadījumā ir nepieciešama papildus informācija par gaisa kuģa kustību (ātrumu, paātrinājumu, ceļu, leņķiskiem ātrumiem un leņķisko stāvokli). Darba tiks piedāvāts vienkanāla sānu inerciālās navigācijas sistēmas modelis ziemeļu kanālā pamatā. Doti 1INS kļūdu modeļa modelēšanas rezultāti. Tiks piedāvāti atšķirīgie sistēmas korekcijas varianti, izmantojot ārējo informācijas avotu par gaisa kuģu kursu. Aplūkoti un nomodelēti vienkanāla sistēmas kļūdu modeļi ar dažādu variantu ievēstam korekcijām un to kombinācijām, ka arī doti rezultāti, iegūti modelēšanas gaitā. Iegūti modelēšanas rezultāti rada uz ievērojamu 1INS precizitāšu raksturojumu uzlabojumu.

P.Trifonovs –Bogdanovs, D.Fetisovs, T. Trifonova – Bogdanova. Одноканальная корректируемая инерциальная навигационная система бокового канала на основе северного канала.

Результаты анализа структурных схем инерциальных навигационных систем (ИНС) указывают на возможность создания одноканальной инерциальной навигационной системы(1ИНС), используя лишь боковой, продольный или вертикальный каналы. В полноканальном варианте, система имеет перекрестные связи между главными цепями каналов, поэтому при одноканальном варианте необходимы дополнительные источники информации о движении воздушного судна. Без внешних источников информации погрешность системы значительно увеличивается по сравнению с полноканальным вариантом. В работе предложена модель одноканальной инерциальной навигационной системы бокового канала на основе северного канала ИНС. Приведены результаты моделирования модели погрешностей 1ИНС. Предложены различные варианты коррекции системы, используя внешний источник информации о курсе воздушного судна.Рассмотрены и смоделированы модели погрешностей одноканальной системы с введеными различными вариантами коррекций и их комбинации, а также представлены полученый результаты моделирования. Полученые результаты моделирования указывают на значительное увеличение точностных показателей 1ИНС.