**"Gyroskopiya i Navigatsiya" №1, 2004**

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| Proposed is circuit design for gyroinclinometer with angular momentum vector of rotor angular velocity transducer (AVT) oriented perpendicular to the hole longitudinal axis. It is shown that such gyro scheme which authors named "cross-cut" in combination with elementary methods (or structure) results at point compassing in removing restrictions for hole horizontal position which is peculiar for generally used (longitudinal) orientation of double-axis AVT. One more important distinction of the inclinometer is the possibility of its calibration during multistage compassing at each start. This cardinal advantage of the "cross-cut" scheme opens the way to creation of gMWD-system with reduction of AVT starting errors that define the errors of point compassing. Such system is especially urgent for tracking shelf drilling with distant and long-distance deviations from the vertical line. |  |

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| **O.A.Stepanov** | **Relation between optimal stationary filtering algorithms and smoothing** | **16** |
| In practice, in signal processing it is necessary to solve both the filtering and the smoothing problem. The algorithms for these problems are basically known and can be derived using frequency or state-space approaches. When random signals are stationary the optimal smoothing algorithm can be realized by processing of the measurements using the filter with the frequency transfer function (TF) (1.9) and then by processing the obtained estimates in the same filter in reverse time. The advantage of this algorithm is the fact that in estimating scalar processes, it is necessary to store and process (in reverse time) only the scalar output of the filter with TF(1.9). The drawback of this algorithm is that the relation between (1.9) and TF for optimal filtering is not evident and one more filter will be needed if both bf these problems (filtering and smoothing) are to be solved. Besides, the frequency approach reduces the class of the problems solved, as this method is only suitable for stationary random processes. A far wider class of problems can be solved by applying methods based on the state-space approach with the use of shaping filters. One of these methods used to solve the smoothing problem also includes two stages. The filtering problem is the first to be solved. Then the filtering estimates are processed in the Kalman-type filter in reverse time. Apart from the fact that this approach provides a solution to a wider class of problems, it allows solving both the filtering and smoothing problem in the framework of a unified algorithm. However, the drawback of this approach is the fact that in reverse time, even for estimating of scalar processes formed with an n - dimensional shaping filter, it is necessary to process and, consequently, store the É-dimensional filtering estimate vector. It is evident that processing of this -dimensional vector in reverse time makes the algorithm more complicated from the standpoint of calculation The paper discusses the problem of developing such algorithm that, on the one hand, includes the filtering algorithm, and, on the other hand, the dimension of the vector stored and processed in reverse time is the minimal. It is considered the case when the shaping filters for processes estimated and their errors are described by time-invariant equations. |  |

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| **M.I.Evstifeev** | **Assembly calculation and design problems for micromechanical gyroscopes** | **27** |
| Taking into account technology features, calculation and design problems of micromechanical gyroscope (MMG) structure creation were discussed. Analysis of requirements for tuning, sensitivity threshold, design parameters stability and strength was implemented. When designing the issues of maximum sensitivity, frequencies characteristics, isoelasticy suspension, manufacturing accuracy should be considered. Results of deformation and strain calculation were derived with use of finite element analysis. |  |

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| **R.L.Voskoboinikov** | **Synchronization of independent orthogonal autoactivated electromagnetic flows in the electrical Machine** | **40** |
| It is shown that non-transformer coupling arises between nearly equal autonomous self-oscillators of electromagnetic flows orthogonally positioned in the closed ferromagnetic space of the ring-type magnet of the electrical machine. This coupling causes phase alignment of the flows and formation of the circular electromagnetic field |  |

**Materials of the 10th Saint Petersburg International Conference
on Integrated Navigation Systems**

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| **A.A. Volyntsev, L.A. Dudko,B.A. Kazakov, V.V. Kozlov,A.P. Mezentsev, V.I. Reshetnikov,D.N. Dibrov, V.S. Rizhkov** | **The High-Accuracy Gyroscopic Instruments for the Attitude Control and Stabilization Systems of Spacecrafts and Orbital Space Stations - the Experience in Design and Development** | **45** |
| Aspects of developing of the high accuracy Strapdown Inertial Reference Unit (SIRU) intended for work in a control system by angular orientation of spacecrafts(SC) are considered. Design features of devices, design principles of gyroscope heat setting system and the precision electronic devices, the realized ways of achievement of raised reliability and a long lifetime are presented. The basic characteristics of devices are given. The estimation of results the SIRU using on spacecrafts of various purposes is given. |  |

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| **A. Jeanroy, P. Featonby, J.-M. Caron** | **Low-Cost Miniature and Accurate IMU with Vibrating Sensors for Tactical Applications** | **58** |
| During the 3rd St. Petersburg conference on Integrated Navigation Systems in 1996 we presented a paper entitled "The Quapason, a new low-cost vibrating gyroscope" [1]. Work on this novel gyroscope, composed of four square vibrating beams, has continued and in this paper we present new results concerning its performance. The QuapasonTM is now in full production and used in many applications. We also discuss two other vibrating inertial sensors, a hemispherical resonant gyroscope (HRG), into which considerable effort are devoted in order to produce a low-cost accurate gyroscope, and a vibrating beam accelerometer (VBA). These sensors will be used together in a miniature inertial measurement unit (IMU) for various medium performance applications. |  |

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| **Yu.N.Korkishko, V.A.Fedorov, V.E.Prilutsky, V.G.Ponomarev, E.M.Paderin** | **High-precision fiber-optical gyroscope with linear digital output** | **69** |
| The closed loop fiber optical gyroscopes (FOG) worked as a sensor of rotation rate ?, is developed. In our design a multi-function integrated optics chip (MIOC) is used for polarization of light, for splitting the light into clockwise and counterclockwise waves, and for electro-optically phase modulation of lightwaves. To achieve high sensitivity and small bias drift, we have used 1070 m long fiber optical coil, made from self-produced single mode (=0,83 m) polarization mounting (PM) fiber (PANDA) with low optical loss (<3dB/km) and high polarization-holding parameter (h<5**.**10-5 m-1). The fiber coil has been fabricated by symmetrical packing with stable stretch. The coil is placed at temperature isolated plate with diameter D~140 mm. PIN photodiode is used as a receiver and pigtailed, temperature stabilized superluminescent diode with output power less then 2 mW is used as a light source. Stabilization of temperature enables one to achieve temperature stability of FOG's scale factor. In this case the Sagnac phase is compensated by saw-tooth modulation of light with calibrated amplitude 2 and frequency *f=*D/(*n*), *n* - effective refractive index of waveguiding mode. The parameters of FOG are following: Bias repeatability, 3 , Ï/h ........... < 0.1 Random walk, Ï/h .................. < 0.005 Scale factor repeatability, % ..... < 0.01 |  |

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| **B.Stieler, C.Eppler, T.Garber, á.Kostikov** | **On the Use of Gyros for Improoving the Tool Center Point Navigation of Industrial Robots** | **83** |
| Navigation errors of industrial robots, i.e. positioning and orientation errors of the "tool center point (TCP)" are in general due to deficiencies of the sensors, the assembly and compliant displacements. For repeated modes of identical sequences under identical load conditions as in mass production many of these effects are overcome by the "teach-in" prior to operation. Not sensor accuracy but repeatability of all the deficiencies is of prime importance. Absolute navigation accuracy opens the way for TCP control right from the design and enables better servicing and exchangeability of devices. This requires an intense calibration of the deficiencies mentioned above during robot manufacturing and servicing.Gyros attached to the TCP open a convenient and accurate way for this task. One gyro package allows the calibration of the angular sensors within all joints of the kinematic chain. The compliance of all links of this chain and of all assembly deficiencies become observable when the output of this package is compared to the ro-bot sensor output or the robot command via the Jacobian matrix. The calibration results will be stored for compensation during operation. The concept is verified by simulation and test results. |  |

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| **S.F.Bylinkin, V.V.Leschev, V.V.Losev, S.A.Zotov, Yu.V.Ivanov** | **Accelerometer Series AT. Condition and Prospects of Development** | **97** |
| Questions of the theory and practice of designing and of experimental researches of micromechanical accelerometers series áô are considered. The equations of movement of a sensitive element and the transfer functions are resulted, allowing to investigate its dynamics. Circuits and transfer functions of the electronic block of accelerometers are submitted. Constructive and technological features of formation of the moment of a feedback are considered. Technical and economic characteristics of accelerometers series áô are resulted. |  |

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| **S.F.Konovalov, A.V.Kuleshov, N.A.Nossov, V.P.Podtchezertsev, V.V.Fateev, E.N.Frolov, K.B.Kwon, S.W.Nam** | **Vibrating Angular Rate Sensor** | **107** |
| In the report represented the information about development and research of three vibratory rate sensors, which are intended for application in the control channel of rotating carrier. These sensors are constructed using the scheme of a rotary vibrating gyroscope. The application of the rotary vibrating gyroscope on rotating carrier allows to use carrier rotation about the longitudinal axis for deriving an angular momentum of a sensing element. This allows to remove the mover of the rotor and considerably simplify the construction, reduces a mass, overall dimensions and cost of the sensor. As the control of rotating carrier happens in the rotate coordinates, the increased requirements to phase characteristics of the output signal are presented. The sensing element of the first sensor construction represents by itself the conducting frame with a coil in the field of the constant magnet. In the sensor the electromagnetic damping is applied. The frame coil signal is proportional to the angular rate of the sensing element oscillations. This sensor has some defects, which influence upon accuracy. They are conditioned by dependence of amplitude and phase of the output signal upon unstable rotation rate of the carrier about the longitudinal axis, and also by dependence of damping on environment temperature. On base of the same design concept the new rate sensor for rotating carrier was developed. For increase the damping stability in the sensor the degenerative feedback on an angular rate of the sensing element oscillations was used. Using the integration of the sensor output signal reduced dependence of the output signal on rotation rate of the carrier about the longitudinal axis. All this allows to increase the sensor accuracy more than ten times. The new sensor represents by itself the non-conducting frame in single-axis free suspension. The plane of the frame is perpendicular to the longitudinal axis of the carrier. On the frame two electrical coils are wind up. The coils are in the uniform magnetic field of the constant magnets which force lines are parallel to the frame plane. One of the coils (sensing coil) is intended for a measurement of the angular rate of the frame oscillations. Other coil (force coil) is intended for creation of the feedback torque, proportional to the angular rate of the frame oscillations. For this purpose the coils connected among themselves by the current transducer. The scheme of the micromechanical silicon vibratory rate sensor is represented also. The sensing element of the device consists of the moving plate and torsion bars. With the help of the torsion bars moving plate is suspended in the case, and represents a solid construction manufactured from monocrystal silicon by the anisotropic etching. The deflection angle of the sensing element is measured by the differential capacity pickup; two capacitor plates are placed on the moving plate and other two - on case. Application of micromechanical elements allows to reduce volume of the sensor, to simplify the construction and to make the sensor cheaper with the simultaneous improving of accuracy performances. In the report represented the data of theoretical and experimental researches of three vibratory rate sensor, obtained formulas which describes the output signal as a function of measured rate and all parameters of the sensor. That allows to evaluate the accuracy of the angular rate measurement in the various operating conditions. In the report considered the constructions schemes and performance of the stands for static and dynamic tests of the vibratory gyroscopes, including temperature tests from -60œó up to + 90œó. The stands contain the simulator of carrier rotation, controlled from the PC, with the sample stage, on which the candidate sensor is installed. The simulator of carrier rotation contains the rotary encoder, which signal is compared to frequency assigned in the PC. In the simulator of rotation there is a digital control system that ensures the maintaining of rotation rate constancy from 10 up to 25 round per sec. The stand for dynamic tests is single-axis gyrostabilizer, on the rotary table of which the simulator of rotation with the candidate sensor is installed. The fiber-optical gyroscope (FOG) is a part of the stand. This gyroscope is the indicator of the table rate. The FOG signal, proportional to rotation rate of the stand table, feed into the PC, where is compared to assigned angular rate. The rotary table allows to produce as rotation of table with a constant angular rate in the range up to 300 œ/sec, as angular oscillations in frequency band up to 7 Hz. In the static stand the simulator is installed on rotary table ensuring the rotation with a constant angular rate in a range up to 1100œ/sec. The angular rate of table is changed by mechanical speed variator. A feature of the stand is the thermal-chamber availability. Thermal-chamber permit to maintain temperature in a range -60œó + 90œó with a step value 0,1œC during the rotation of stand table. The thermal-chamber has a digital control. As a cooling agent in the camera the liquid nitrogen is used. The data of stands and thermal-chamber certification and test data of vibratory rate sensor are presented. |  |

**Materials of the 23th Conference in memory of N.N.Ostryakov**

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| **S.P.Dmitriev, N.V.Kolesov, A.V.Osipov** | **Testing and diagnostics of informational abnormalities in navigation systems by methods of multiple-choice filtering** | **119** |
| The problem is considered for navigation system (NS) testing and diagnostics. Data failure and NS abnormality conceptions are introduced. The suboptimal algorithm based on multiple-choice filtering is proposed for their testing and diagnostics. The algorithm proposes calculation for all failures of a posteriori probabilities on which ground the decision on the most probable abnormality is made. The bank of Kalman filters and poly-Gaussian approximation of a posteriori probability density for the state vector of NS error model are used in the algorithm. Modeling results confirming the effectiveness of the proposed algorithm are presented. |  |

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| **A.G.Mikerov, D.V.Samohvalov** | **Digital correction of static characteristics for actuating ac electronic motors** | **126** |
| It is known that static and dynamic characteristics of permanent magnet synchronous motor (PMSM) are similar to a classic DC motor. However it is valid only for an "ideal" PMSM without any time delay in electronics and a stator winding. For a small PMSM the electromagnet time constant of the stator winding is very small and the major factor is a time constant of electronics. To compensate time constants in PMSM static correction algorithms are employed. In the paper the effectiveness of a simple static correction algorithm is experimentally explored. The set up includes the synchronous motor DBM66 with outside diameter 63 mm, no-load speed 6000 rpm, max output power 11 W and electromagnet time constant 1.12 msec. It has the resolver VT60, as the rotor position sensor, linear power amplifier and INTEL80196MC microcontroller with a static correction algorithm. It was possible to tune the static correction to compensate of electronics time constant in the range 1 - 3 msec. The best result was obtained for the algorithm with the time *constant a.b msec which is close to the experimentally tested value for set up electronics. This algorithm provides the PMSM no-load speed increasing c.d times, current* consumption decreacing t.f times and high linearity of the speed versus control voltage characteristic. Therefore the employment of static correction algorithms are very useful in servodrives not only for high power (dozens kW) but for small motors less then 0.1 kW too. |  |

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