ELECTRIC ACTION SYSTEM FOR SATELLITE DISH ORIENTATION

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Abstract. *Telecommunication satellites generally are geostationary, usually placed over the equator and having a constant rotation speed equal to that of the Earth, thus, the satellite related to a fixed point on the surface of the planet will never change the position toward that point; this orbits are also called geosynchronous.*
Keywords: *telecommunication, satellite, orientations.*

Level measurement in big open vessel

The satellite is orbiting because of the initial impulse received during the launch. The satellite is kept on the orbit by the mechanics of the sky; the gravity of the earth is compensated by the centrifugal force that tends to wrests it from the orbit.

If the synchronism condition is not carried out, the satellite will not return to its initial position towards the earth, after a revolution period. Although the satellite has a periodical motion supposed ideal, the sub-satellite draws a incomplete trajectory around the spinning Earth.

In order to follow the satellite, the geographic coordinates must be known, that is the longitude and the latitude towards the main meridian.

The majority of satellite transmissions are digital, thus information regarding the channel list or re-transmissible stations, are also possible to receive. In this way the receiver will have complete information regarding the satellite re-transmitted channels (after a complete scanning of the frequency spectrum), fact that could help in the realization of a bi-directional interface with the receiver: the channel list and additional data of every channel (frequency, polarization, digital transmission parameters, etc) will be received by the receiver, and the user will be able to select the right channel from the list, ability that affect the transmission of the selection order back to the receiver.

Therefore, this bi-directional order transmission will become transparent to the user, gaining in this way the aimed flexibility. For professional and large systems, these programs (order algorithms) have incorporated error-correcting mechanisms (the absolute position is compared to the aimed one), fact that involves a closed lock in order to integrate the error in the calculation of the real position; commanding system of the stabilizer fail-safe (from the deviations caused by the wind), protection mechanisms, emergence blockages, etc.

Electric operation systems used on the orientation of the satellite dish

Particularly about electric operations used in orienting the satellite dish systems, the complexity, structure and power are dependent on a series of factors as:

- the size of the dish that can vary from 0,6 m to 25 m
- the compelled accuracy of the system
- the power of the electric engine
- the type of engine used in the process (MCC or MPP)
- the order system in closed or opened circuit, numerical or analogous numerical

In accordance with these requirements, the structure and complexity of the power converter and order algorithm are modified. The monitoring and control system M&C, generates the order size, according to the imposed requirements and the status signals received from the order equipment. The order equipment, analogical or numerical, takes over the prescribed sizes generated by sensors (current and/or tension) and translators (of velocity and/or position) and on this account commands the power converter. This transfers the energy of the charging source, the engines that move the dish system in the ordered coordinates (azimuth and elevation).

The control unit must do 3 major tasks: interpret the data stream received from the monitoring and control system (M&C) for determining the position of the antenna and then return the processed data to the M&C system; other logical tasks. The control units of the antenna check the azimuth and elevation using a preset number of bits.

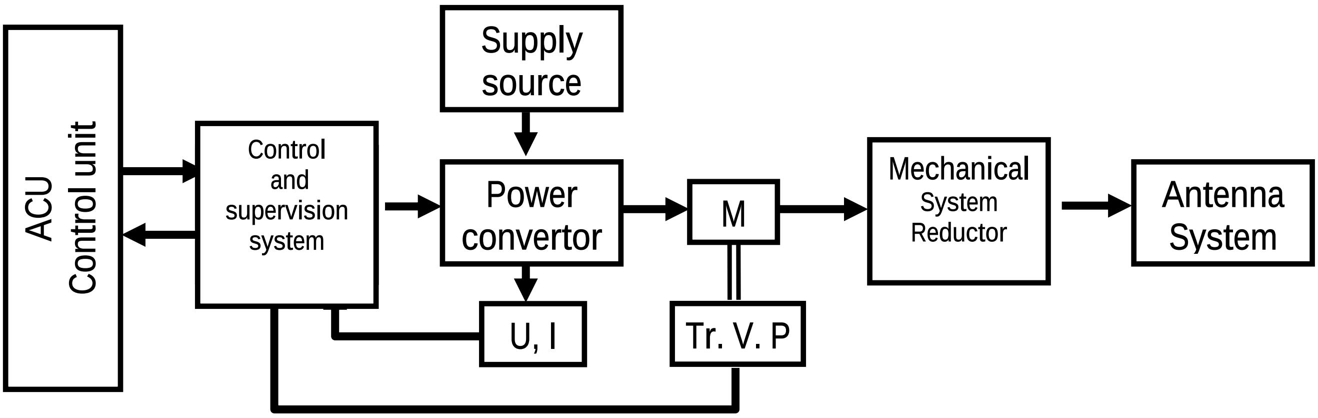

Figure 1 The bloc scheme of a system of electric actuation, for big size antennas

Tracking satellites using a satellite dish

Due to very big distance existing between satellite and ground stations the antenna systems are projected in the sight realization of the features of very radiations lines, the source of radiation will be placed in the focal point of a parabolic reflector which concentrates the electric-waves in a the narrow fascicles, directed to antenna of reception, in fig. 2.1 are presented schematically antennas with parabolic reflector which have the source of radiation putted in the paraboloid focus or which own an auxiliary hyperbolic or parabolic spotlight. Constructive spread has the auxiliary reflectional hyperbolic that is Cassegrain antennas. A prerequisite for working precisely is that the system has to have a correct satellite antenna orientation toward Earth and the ground antenna has to be orientated accurate.

The system of orientation for satellite antennas depends on the way in which is obtained the stabilization of the satellite on orbit:

- For situations in which the stabilization is done through rotation of the body of the satellite, antennas are installed on an platform that rotates in opposite senses.

- The orientation of the systems from earth of big sizes(25-30m) raises different problems, because these have the weights of tens or hundreds of tons and the accuracy of satellite pursuit is due to be is very big

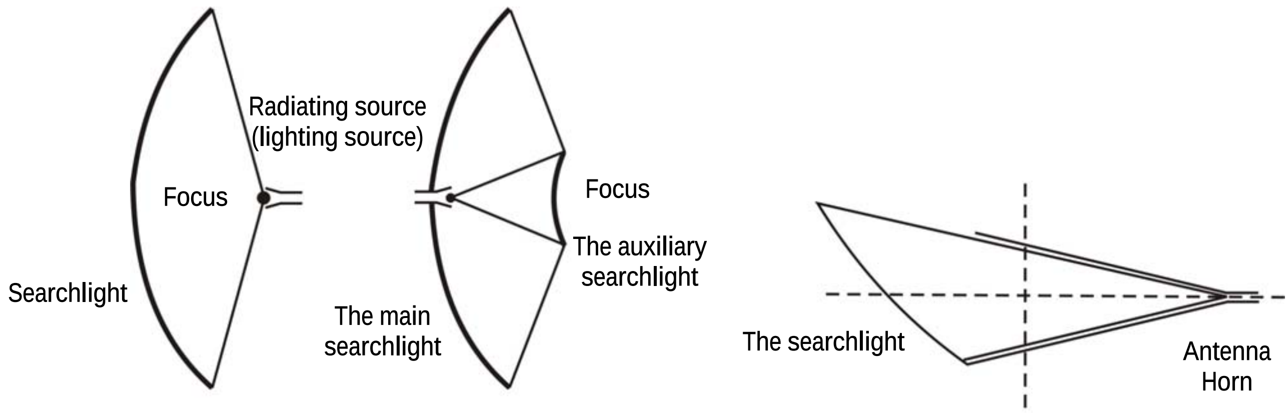

Figure 2 The schematic representation of antennas with reflector

The satellite pursuit

The satellite pursuit systems can be automatic (with closed loop) or programmed (with open loop) when the orbital coordinates of the satellite are transmited from the computer.

The tracking receiver takes over the angular errors seen by the systems, remakes them and amplifies them up to the necessary level of operation for the servo-systems.

The two systems have advantages and disadvantages :

- The functioning of the automatic system is stricken by the signal/ perturbation report, when the satellite is near a source of cosmic noise.
- The automatic system can generate errors in analyzing and interpreting the commanding data.
- The programmed system uses the pre-calculated orbital data of the satellite, and is not stricken by the cosmic radio perturbations.
- The programmed system allows the quick localization of the satellite position on the sky, at a certain point.
- The ground stations are equipped with both systems because of security reasons.

The operation of the dish system is problematical because of the weight of the location on which they are situated (tons or tens of tons), the gearing , the power of the electric engine that must assure the angular velocities and accelerations imperative for the motion on elevation or azimuth, in any atmospheric condition.

Particular case, for a dish X-Y (azimuth-elevation) the elevation angle varies between 0° and 90°;

the azimuth varies between 0°÷ 360°

because of the weight of the motion systems, the maximum attainable velocities and accelerations are limited by the admitted powers of the electric engines. The dish system can follow the satellite, only if the elevation is lesser that a certain value caused by the existence of the still cone. This situation appears if the motion of the satellite is supposed in a constant azimuth plane and with an increasing elevation, staring from null and going close to 90°. When the elevation reached 90° and the satellite, in its motion moves further, thus growing the elevation, the following of the satellite is no longer possible, except by the means of a instant 180° azimuth rotation of the dish, thing very difficult to realize because of the ineptness mass of the dish system.

The analysis of the following systems presupposes the cognition of the characteristic expression of following lightening radiation. The received signal of one of the lobes is written:

$$e = U(t) f(\beta) \cos(\omega_0 t + \psi)$$

Because of its harmonic nature, with ω throb and ψ phase difference and with the amplitude varying in time (because of the modification of the propagation conditions) and dependence on the β angle, the one between the axle of the cone and the direction of the satellite. We consider an elevation plane in which the satellite is. The intersection of this plane with the lobes 1 and 2 is described in the figure 3.a and 3.b, where are indicated the axis OD1 and OD2 of the lobes, the mirror line OM, the direction of the satellite OD and are specified the angular coordinates γ0, γ, D1 and D2. It can be seen that

$$\beta_1 = \gamma_0 - \gamma, \qquad \beta_2 = \gamma_0 + \gamma$$

and the signals obtained on the account of the lobes 1 and 2 are thus deduced.

$$e_1 = U(t) f(\gamma_0 - \gamma)\cos\omega_0 t$$
$$e_2 = U(t) f(\gamma_0 + \gamma)\cos\omega_0 t$$

presupposing ψ = 0. signals e3, e4, obtained from the lobes 3 and 4 have similar expressions.

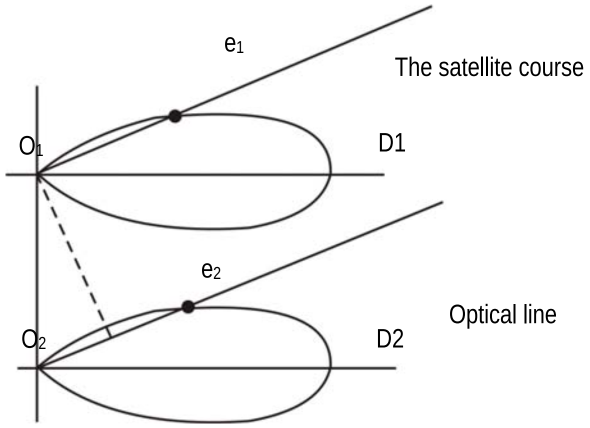

Fig. 3.a – The phase monopulse system

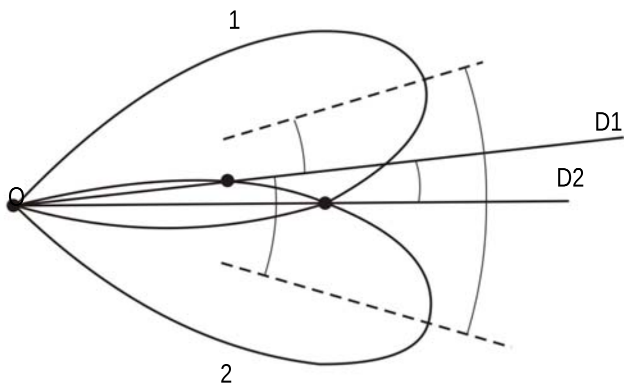

Fig. 3.b – Angle coordinates

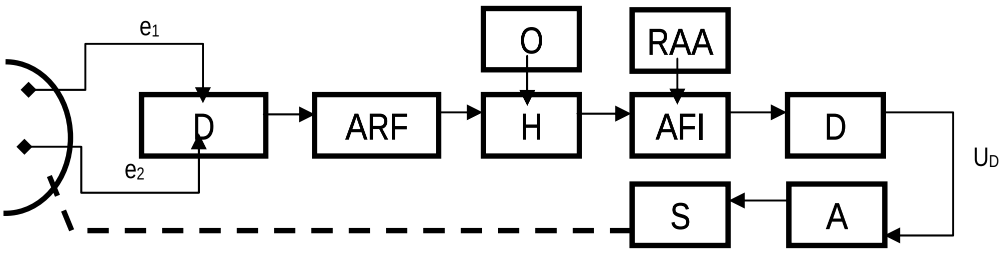

Fig. 3 – Angular error receiver scheme

The elevation or azimuth error receiver also called tracking receiver, is depicted, mainly in scheme 3.2. It is a super-heterodyne receiver that amplifies the difference e2-e1, de-modulates it, and transmits it to servo-system S through an amplifier A; this one applies, by a mechanic connection dotted drawn, the couple imperative to the rotation of the dish in the direction of the satellite, a0, being a constant. It is ascertained that the size that commands the servo-system is proportionate with the angular error y.

Because the servo-system reacts for reducing the error, it assures the ordering of the removal line of the dish in the direction of the satellite, in a dynamic procedure for error annulling.

Small dish orienting systems

The manual dish orienting implies a high discomfort. A dish monitor system is preferred, more or less automatized.

The classic supervising of the dish, involves the usage of an actuator, a device that turns the orienting rotation motion of a electric engine into a translation movement that moves the dish on a East-West track. The antennas must be equipped with a polar bead. The method assures a high safety, a low price and can be used for a large scale of antenna dimensions. That is why at the moment, it is used at a large scale.

Other orienting methods also exist, bead with incorporated rotation system or LNB motion system that presents a series of disadvantages, namely:

- the receiving is limited at a small number of satellites
- high cost price

Necessary equipment

The actuator represents the motion implementation element. Its main characteristic is the range evaluated in inch ("). The actuators can be acquired from the market in the 6"-36", but the most customary values are 8", 12", 18" and 24".

The range of charging tensions of the actuator engines is comprised between 12V and 36V.

The working current depends on the used task, frictions, velocity of wind and can vary from 0,4A to 1,5A for an antenna of 1,5 m charged at a tension of 36V.

For sensing the rotation movement, the actuators can be equipped with a sensor. This sensor allows the estimation of the antenna position in any moment, and allows the movement on the coordinates of the satellite. The sensor is a reed relay, that needs supplementary fueling, or optic or Hall effect.

The positioner is an electric device, presented as a different device or included inside a receiver, that is ment to command the actuator. It must be capable to provide to the actuator the voltage and the current necessary to the functioning, and at the same time the complex positioning system, monitor the position of the antenna with the help of the observing position element, performs the sharp adjustment of the polarization in order to obtain a quality reception.

DiSEqC (Digital Satellite Equipment Control)- fig.4- automat positioner was conceived by EUTELESAT to control a large range of accessories connected to the satellite receivers.

A signal having a frequency of 22Khz modulated in amplitude is used to forme the data and message bites.

In principle, the value of the logic “1” represents the burst of 0.5ms of a 22kHz signal (with the amplitude of 0.6V) is followed by 1ms pause, and the value of logic “0” represents the burst of 1ms followed by a 0.5ms pause.

The bites are grouped in bytes, each byte having 8 bites and a parity bite.

A DiSEqc command has 3 or 4 bytes. The first byte is named “the framing byte”, the second is the address byte followed by the command byte and only if necessary the data byte. The end of each command is represented by the pause in the 22kHz carrier. The DiSEqC commands can coexist with the 13/17V current commands and with the “Tone Burs” commands.

The logic is implemented in the software of the receiver while the infrastructure that assures the actuator command (the power source, the memory that stocks the satellites and impulse counter) belongs to the positioner. This structure has the advantage that separates the power source from the sensitive circuits of the digital receiver without extra wiring

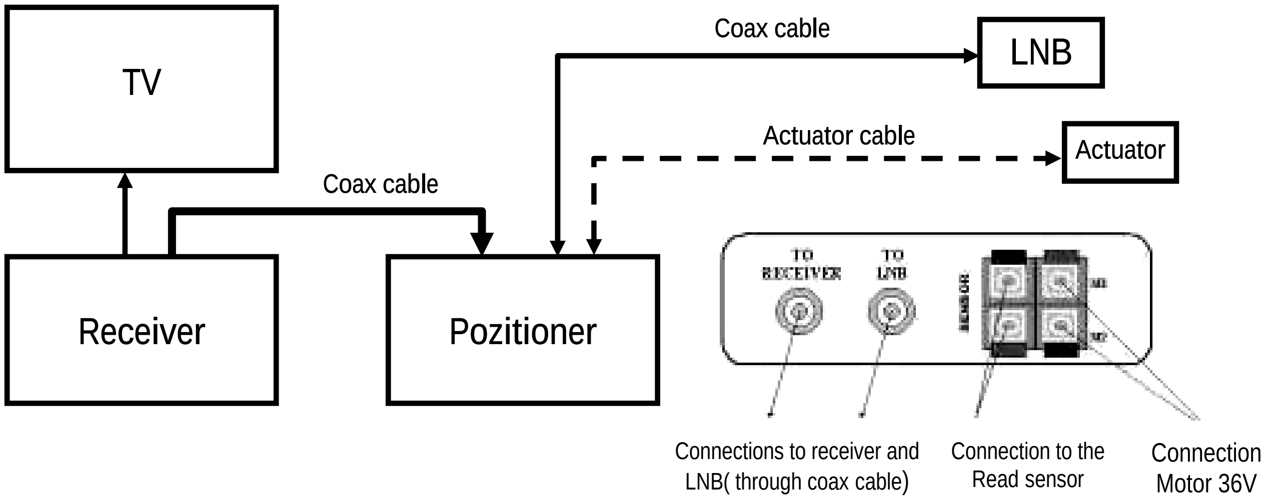

Fig. 4. the connections necessary to the using of the positioner SRT V50. The receiver is connected to the LNB through positioner. This one decodes the commands transmitted through coaxial cable in DiSEqC 1.2 and commands the actuator. The connection between the positioner and actuator it is done through 4 wires: two (M1, M2) for the tension of the engine, and the other 2 (SENSOR) for the reaction impulses.

Practical aplication: Control software

The purpose of the scheme below is to help the ones who want to control parabolic antennas with the help of a computer through a special software that can be easily adapted to any requirements. This programme can be used in aplications with systems of medium and high power, being easily aplicated and adapted in order to offer to everyone a great fiability.

The functional bloc scheme

This programme is practically realized of three modules: the entrance module, the exit module and an intermediary settings module.

The entrance module: its purpose is to help either the ones who know or the ones who don't know about the satellites and the parabolic antennas orientation. This can be done by giving the user the possibility of choosing the right way of introducing the coordinates of the satellite: introducing the coordinates of the satellite manualy (azimuth, elevation) offers the interested ones great flexibility and choosing a satellite from a list ends with setting up the coordinates of the satellite.

The exit module: the chosen coordinates or the ones manualy introduced are being sent towards the exit. This thing can be realized by sending to the paralel or the serial port impulses that represents the sequence of steps of an MPP (or MCC) to be done from the old position toward the new one, and tis is the position of the antenna.

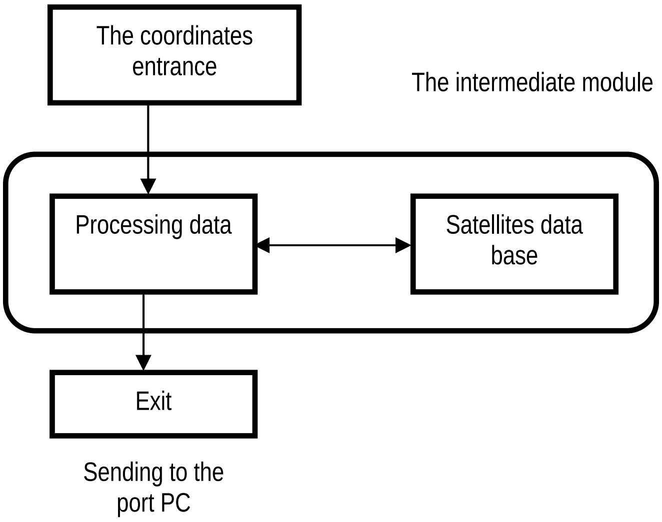

Fig. 5 The bloc scheme, the control software

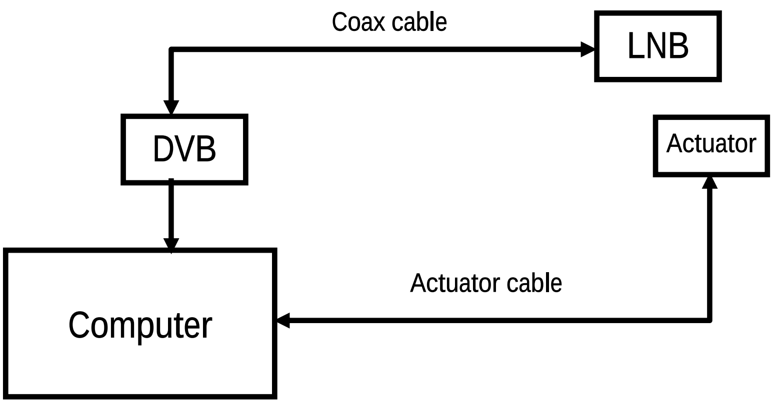

Fig.6 The command bloc scheme of the satellite antennas and reception of the digital programmes

The scheme above shows how to command the systems of antennas of small or great power, through the help of a special soft that uses the serial or the paralel port and the MPP or MCC as an execution element.
At the same time, with the help of a computer, there can be received a great number of digital uncoded programme with the highest quality of the image. While in the clasical scheme the elements of reception were composed of: antenna, LNB, receiver, TV- set , in the scheme below the satellite receiver and the TV- set are replaced by the computer.
The novelty element is represented by the capture dish – DVB, capable of uncoding the low frequency signal received from a LNB in multimedia stream, that can be used from a computer.

Electric engines used in polar orienting systems

The electric engines used operating polar orienting systems can be: direct current engines, or step-by-step engines, boosters, tachogenerators etc.
The direct current is used due to some performances, as:

- the possibility of modifying the revolution, realized through the change of the terminal tension,

- the possibility of usage in applications that need variable revolutions and the control of the couple.
- through an adequate projection there can be obtained engines capable to work at reduced revolutions in electric operations, and that are capable to eliminate the heat educed by the rotor current
- it can be used at a large scale of applications from the miniatures to the largest ones.
- the commanding of these engines is simple, as there are used impulse modulation circuits in duration (PWM)

Step-by step engines:

-positioning accuracy and high resolution

-it can be used in open circuit

- memorizes the position

- is compatible with the numeral command

- assures univocity of the impulse-dislocation number conversion

- large scale of command frequencies

- allows startings, stations and deluges without loosing steps

Mpp, created to be digitally commanded, proved to have several main disadvantages:

- looses steps at large loadings if the command frequency of the windinind is high, MPP cannot be commanded through high frequency and loaded with maximum charge as initially estimated.
- the electronic command scheme is rather complex
- the increase of the advanced couple involves the increase of the of the command scheme complexity
- the energetic rated capacity is low because of the constant current command of the windings.

It is thus ascertained a restraint, in the last years, of the usage domains of the MPP, this being used particularly in reduced power applications

Direct current boosters for precision positioning

It is about direct current boosters with or without brushes that can be assembled with ovoid, cylindrical or planetary reducers. Every engine/reducer combination has its characteristics, characteristics that can be found in the product descriptions.

The main features of these engines are: reduced mechanic inertia, reduced electric loses, electric contacts made of precious metal, bearings made of sintered bronze with auto-lubrication.

In the followings, some characteristics of the Portescap engine of this category will be presented

Technical characteristics:

- the feeder tension 6V 12V 24V
- speed (rpm) 5600 5800 8400
- cuplu de antrenare (mNm) 10,5 8,7 10,4
- power (max) (W) 3,8 3,8 3,8
- current (max) (A) 0,72 0,34 0,22

Rotation transducer

Beside the electric engines, a very important equipment is the rotation transducer, able to deliver information about concerning the sprocket, speed and the sense of actuation. In this case also, the bid is varied, an example being the transcriber Kuebler. This is a special type, assuring the compensation of the temperature and the protection to short-circuit, and its answer being of 1024 impulses per rotation.

The transducer can be feeded to a tension of 5-24Vdc, but he can be used to 5V output of the RS422.

Technical characteristics:

- maximum speeds of 12,000 rpm; Moment of inertia of rotor: 0,1x10-6kgm2
- the couple: 0.0001Nm, Radial load on arbor: 10N(At an end the arbor)
- axial load on arbor: 15N, the load: 0,06kg Aprox.
- the working temperature is from 20 C to + 85 C; Consumed current(without load): max. 50mA

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