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Computational Analysys on Three Axis Antennae Stabilization System

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Abstract: *The antennae a stabilization system called 3-axis antennae stabilization system is developed. deviation of antenna through some angle and is tracked by the position sensor. The incremental encoder is used as sensor , it receives signal from the PLC and the tilt sensor which senses orientation /tilt sends a signal. Which is compared with the reference at comparator and the difference signal is sent to PLC for making necessary corrections in the tilt. Satellite antennas are used in rolling and pitching requires stabilization in order to accurately receive or transmit data. In many defense and space application require telemetry, tracking, command and control signals to guide Missile trajectory to hit a target or place satellite into space. Main aim is to reduce the speed, weight and height of the existing configuration. For reducing the speed we replaced the existing drive gear azimuth by gearbox so as to get gear ratio 16:1. All parts are modeled by using the CATIA software and analysis with ANSYS software. The moment of inertia and weight of existing system is compared with modified system using the CATIA software. Using that inertia weight of the system and torque of the motor is calculated from that the motor is selected.*

I. Introduction And Literature Review

Antennae used in radio frequency communication can be classified into directional and Omni-directional. Usage of antennae type depends on the application. Omni directional antennae transmit the energy uniformly in all the directions and can receive the signal, the signal irrespective of the direction. Directional antennae transmit and receive the signal as the name indicates, in a particular orientation. Directional antennae have the advantage of providing high gain increases, the beam width narrows and allowable limits on the physical orientation of the antennae decreases. Schematic of radiation envelop of a directional antenna is shown in fig1. The link will be at desired level when the antennae are within the beam width of each other.

Ships and other floating vessels in marine environment are continuously subjected to varying pitch, roll and yaw motion by sea waves and winds. The amplitude of pitch and roll movements can be as much as +/- 30°, depending upon the size and stability of the vessel and sea state. Hence, directional antennae used on marine floating vessels have to be stabilized to keep them within the signal envelop of each other, by coupling the transmission and reception characteristics of the movements of the floating vessels.

II. Need of stabilization systems:

The context of usage of the system is for radio frequency (RF) communication between two floating vessels involved in flight trail in sea environment. One of the floating vessels is an unmanned launch and the other communicating vessel is at a safe distance from the first. R.F antennae which are wired to the launch platform. The buoy is under constant disturbance and may tilt up to +/- 30° with cycle time ranging from 10 to 20 sec. The RF antennae used in the context are directional in nature with a conical beam envelop. Communication failure due to the aforementioned reason between launch platform and the ship which controls the launch will affect the mission adversely. Hence the antennae stabilization is essential for mission success.

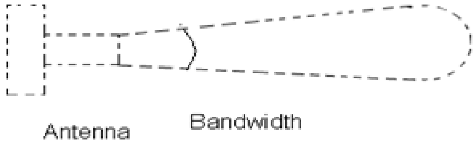


Fig 1 Directional antennae

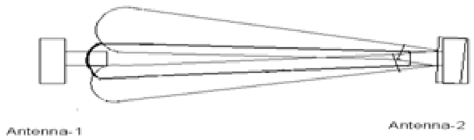


Fig 2 omni Directional antennae

A three-axis antenna positioner has an X-Y over azimuth configuration, and includes an azimuth drive assembly, an X-axis drive assembly, and a Y-axis drive assembly. Each drive assembly is independently operable. The azimuth drive assembly imparts 540° azimuthal rotational motion to an antenna about an azimuth axis. The X-axis drive assembly rotates the antenna about a horizontal X-axis at elevation angles between −90° and +90°. The Y-axis drive assembly rotates the antenna about a Y-axis at elevation complement angles between −2° and +105°. The azimuth axis, the X-axis, and the Y-axis all intersect at a common intersection point, and are mutually orthogonal. A controller operates each drive assembly so as to minimize antenna tracking velocity and acceleration. Each drive assembly may include dual drives, and may be operated in a bias drive mode to substantially eliminate backlash.

As the above patent in my project also the X-axis drive assembly rotates the antenna about a horizontal X-axis at elevation angles between −25° and +25°. The Y-axis drive assembly rotates the antenna about a Y-axis at elevation complement angles between −25° and +25°. The azimuth axis, the X-axis, and the Y-axis all intersect at a common intersection point, and are mutually orthogonal. A P.L.C controller operates each drive assembly so as to minimize antenna tracking velocity and acceleration.

Aim of my project is to reduce the weight of the system by using the planetary gearbox so for reducing the weight we modified this project by using the gearbox. We use two stages for reducing the speed more and getting more torque.

PLC compared with other control systems:

PLCs are well-adapted to a range of automation tasks. These are typically industrial processes in manufacturing where the cost of developing and maintaining the automation system is high relative to the total cost of the automation, and where changes to the system would be expected during its operational life. PLCs contain input and output devices compatible with industrial pilot devices and controls; little electrical design is required, and the design problem centers on expressing the desired sequence of operations in ladder logic (or function chart) notation. PLC applications are typically highly customized systems so the cost of a packaged PLC is low compared to the cost of a specific custom-built controller design. On the other hand, in the case of mass-produced goods, customized control systems are economic due to the lower cost of the components, which can be optimally chosen instead of a "generic" solution, and where the non-recurring engineering charges are spread over thousands of places.

For high volume or very simple fixed automation tasks, different techniques are used. For example, a consumer dishwasher would be controlled by an electromechanical cam timer costing only a few dollars in production quantities.

Design and Working Principle:

The heart of the planetary gearbox is the reduction group composed by the sun pinion (1) and three or more satellites (2) mounted on pins (4) which are supported by the satellite carrier (5). The sun pinion transmits it's motion to the satellites. The satellites then turn inside the ring gear (3) which is static. As consequence the satellite carrier rotates. The motion of the carrier can be transmitted to an output shaft or to another reduction group. The reduction obtained is determined by the relation between the number of teeth on the sun pinion (Z1) and the number of teeth on the ring gear (Z2).

The ratio can be calculated using the shown formula [i=Z2/Z1+1]

One of the planetary gearsets from our transmission has a ring gear with 72 teeth and a sun gear with 30 teeth. We can get lots of different gear ratios out of this gearset.

Also, locking any two of the three components together will lock up the whole device at a 1:1 gear reduction. Notice that the first gear ratio listed above is a reduction -- the output speed is slower than the input speed. The second is an overdrive -- the output speed is faster than the input speed. The last is a reduction again, but the output direction is reversed. There are several other ratios that can be gotten out of this planetary gear set, but these are the ones that are relevant to our automati transmission.

Momentum of inertia of antennae part before modification:

Calculation of moment of inertia for azimuth axis

Component name	Material	Weight	Momentum of inertia
1.antennae	Al	1.996	0.085
2.Bracket	Al	9. 47	0. 067

Calculations of moment of inertia for elevation axis

Component name	Material	Weight	Momentum of
Antennae	Al	1.996	0.589
Bracket	Al	9. 47	0. 149

Calculation of moment of inertia for rotation axis

Component name	Material	Weight	Momentum of inertia
Antennae	Al	1.996	0.576
Bracket	Al	9. 47	1. 094

Table Showing Mass, Moment Of Inertia And Radius For Whole Assembly In Three Axes

S.NO	AXIS	MASS(KG)	MOMENT OF
1.	AZIMUTH	11.466	0.251
2.	ELEVATION	11.466	1.607
3.	ROTATION	11.466	2.525

Momentum of inertia after modification

Calculation of moment of inertia for azimuth axis

S.NO	Part	Mass(kg)	Moment Of Inertia	Density	Ra(mm)
1.	Antenna	1.996	0.061	2710	174.297
2	Bracket	1. 05	0. 002	2710	46. 36

Calculations of moment of inertia for elevation axis

S.NO	PART	MASS(kg)	MOMENT OF INERTIA	DENSITY	Ra(mm)
1.	Antenna	1.996	0.721	2710	600.179
2.	Bracket	1. 051	0.136	2710	359. 85

Calculation of moment of inertia for rotation axis

S.NO	PART	MASS(kg)	MOMENT OF INERTIA	DENSITY	Ra(mm)
1.	Antenna	1.996	0.779	2710	623.425
2.	Bracket	1. 051	0.134	2710	356. 93

Whole Assembly In Three Axes

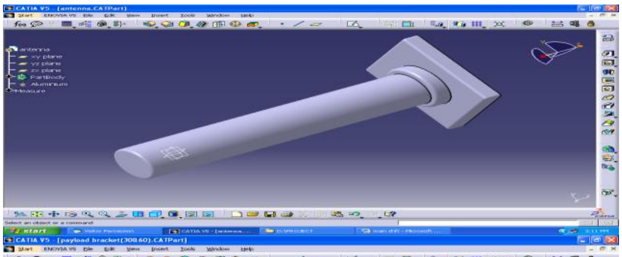
S.NO	AXIS	MASS(KG)	MOMENT OF INERTIA (kgm^{2})	RADIUS(MM)
1.	AZIMUTH	3.046	0.126	138.82
2.	ELEVATION	3.046	1.594	385.432
3.	ROTATION	3.046	1.715	400.843

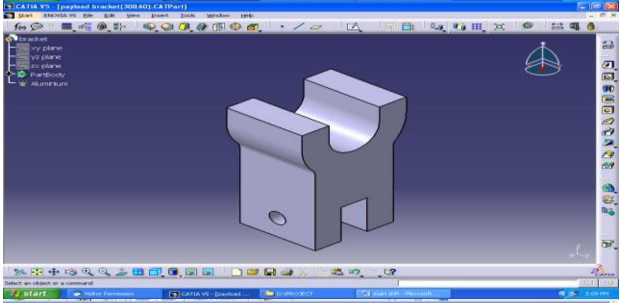
How to work this system:

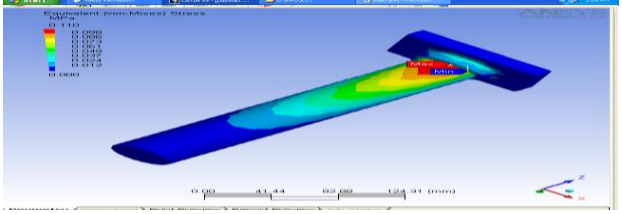
When antenna tilts to some angle that angle of tilt is recognized by tilt sensor. As per the above P.L.C controller the input to the controller is from sensor and output to the motor. In my project the input to the controller is from tilt sensor and output is to brushless D.C motor. Tilt sensor sends signals to P.L.C controller then P.L.C controller sends signals to motor then motor shaft rotates the shaft of the system through gearbox and gears. One encoder is placed in the motor for giving the signals to the required motion of the motor shaft.

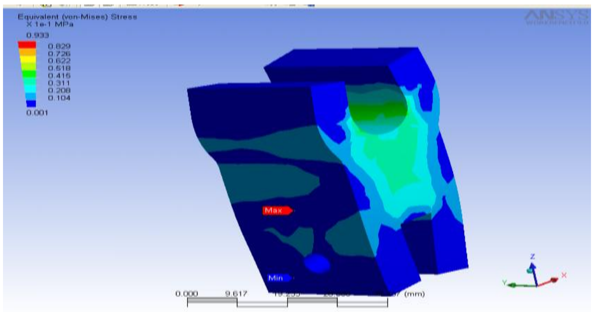
Modeling:

Modeling of three axis antennae stabilization system has been done by CATIA V5R15, various types of modules present in CATIA, like sketcher, part Design, assembly Design, Drafting, structural design, analysis and simulation, NC manufacturing ; in sub type: solid, composite, sheet metal, bulk are there. By choosing the part module & solid as a sub type various parts modeled. By considering the standard values, according to the shape of the part are done in 3D model. For getting the 3D model extrude, revolve options are selected. For extrude option material is added in Z direction where as in Revolve option material is added in 360 degrees.









III. Conclusion

The weight of the system is reduced to 8.42 kg.by calculating moment of inertia and the stresses are found which will be in safe design

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