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Subject Control of Scan Platform Orientation

The scan platform provides a single degree of freedom means for rotating the LAPI about the pitch (+Z) axis of the DE-B. Rotational position is defined as the angle, ϕ, between a fiducial line on the platform and the +X axis of the spacecraft. ϕ is positive clockwise, i.e., rotation from +X to -Y in spacecraft coordinates. Figure 1 illustrates the coordinate system. The fiducial line is parallel to the 0° LAPI detectors in the X-Y plane.

A control magnetometer which rotates with the scan platform is mounted with its sensitive axis normal to the fiducial line. If the component of the magnetic field is in the -Y direction when ϕ = 0°, the sign of the control magnetometer output is positive.

The orientation of the platform may be controlled either by the direction of the component of the earth's magnetic field through the magnetometer, or by ground command. Power to portions of the motor drive electronics is turned off when the platform is not being re-oriented to reduce heating of the motor and to reduce the energy drain from the spacecraft power system.

The scan platform will accelerate to a rotational rate of 84.375° per minute in a prescribed direction following a command to rotate either from the LAPI magnetometer command or spacecraft command. The platform ceases to rotate when the rotation command is disenabled.

No DE-B system requirement constrains the rotation rate to the 90° ± 10% per minute range specified in the Scan Platform performance specification. 84.375° per minute was chosen since it was convenient to implement this rate in the design, and the rate is within the range specified in the performance specification.

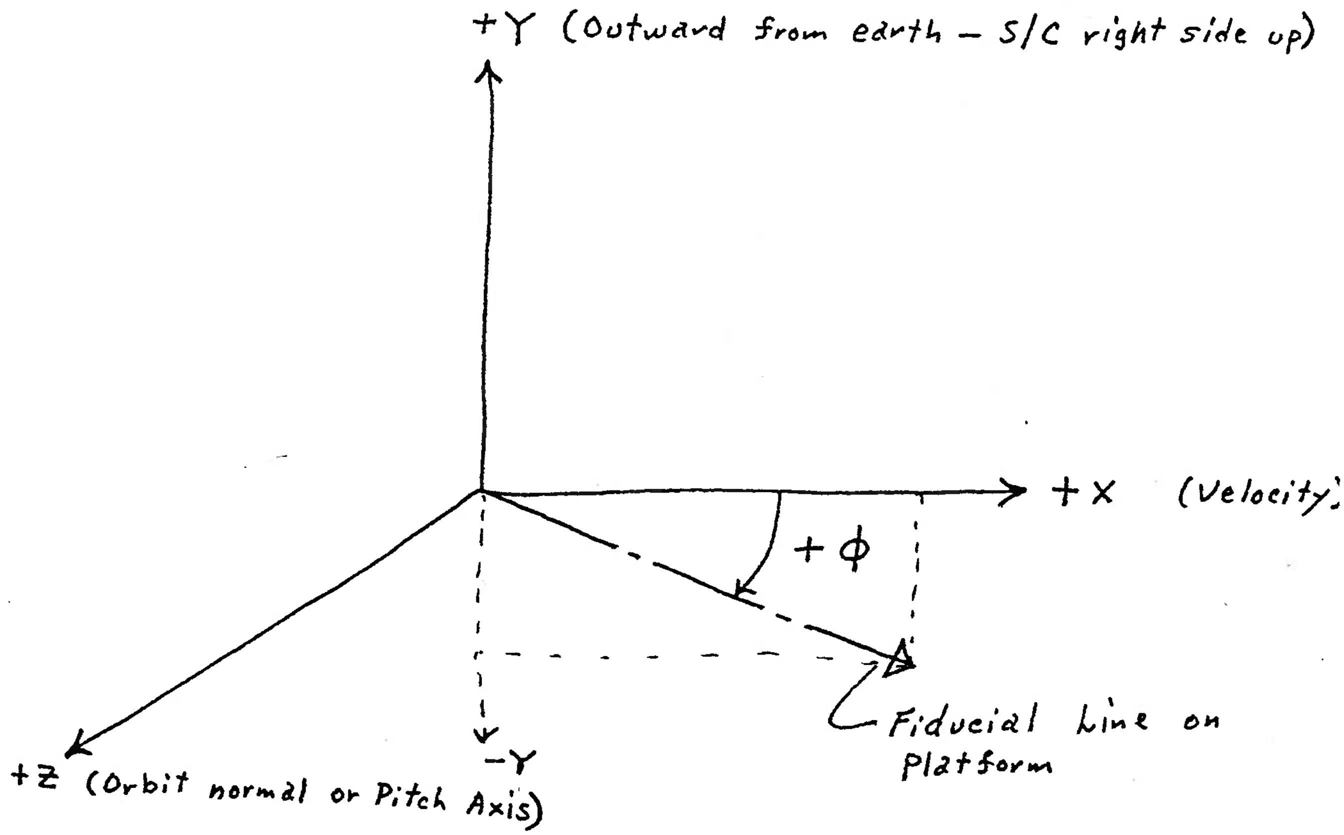

Figure 1. Coordinate System and ϕ Definition

The required precision of positioning the platform either through LAPI magnetometer control or through spacecraft command system control is not extreme, a degree or so of the specified position is adequate. Knowledge of the platform position through telemetry to an accuracy of ±0.175° with a resolution of 0.35° is provided however.

Scan Platform Operation Through LAPI Control

The LAPI magnetometer may control the scan platform to nominally align the fiducial mark (a) parallel to the field component in the X-Y plane, (b) anti-parallel to the field component in the X-Y plane, or (c) at an offset angle relative to either of the above determined by a commanded value and the strength of the component of the field in the X-Y plane. Signals supplied by the LAPI to the scan platform electronics consists of a logic level run/stop signal, and a logic level ϕ negative (counter clockwise) or ϕ positive (clockwise) direction signal.

Upon receipt of run enable and rotation direction logic signals from LAPI, the scan platform motor drive electronics will be energized, and will accelerate the motor to a speed of 84.375° per minute in the proper direction. The platform will continue to rotate at this rate until the LAPI commands the platform to stop rotating at which time the motor drive electronics is de-energized and friction stops platform rotation. The amount of rotation per run-stop cycle is controlled by the design of the LAPI Magnetometer logic circuits, and will probably be in the order of 0.5 to 2.0 degrees. If it is desired that the fiducial mark rotate to a specified offset angle relative to the field direction, a digital command sent to the LAPI Magnetometer Logic Circuits enables the logic circuits to issue proper run-stop commands. Platform angular position with an accuracy of about ±0.175° will be available through telemetry.

Figure 2(a) and Figure 2(b) illustrates a means for controlling scan platform motion from magnetometer output signals. The control sequences are described by the following definitions in conjunction with Figure 2(a) and Figure 2(b).

θ_B = Direction between the component of the earth's magnetic field in the X-Y plane and the fiducial line.

θ_M = Direction between the null axis of the magnetometer or fiducial line and the earth's magnetic field.

B = Earth's magnetic field intensity component in the X-Y plane.

K_1 = Value of $B \sin(\theta_B - \theta_M)$ for which the scan platform motor will be de-energized if $|B \sin(\theta_B - \theta_M)| \leq |K_1|$

K_2 = Value of B sine $(\theta_B - \theta_M)$ for which the scan platform motor will be energized if $|B \sin(\theta_B - \theta_M)| \geq |K_2|$

The platform will orient the fiducial line either in the direction of (Parallel) or opposite to the direction of (anti-parallel) the magnetic field depending upon the sign of the direction of rotation command from the magnetometer logic as a function of the sign of $B \sin(\theta_B - \theta_M)$. This can be controlled by ground command.

The direction of the fiducial line can be offset from the direction of B by an amount θ_0 by arranging the Magnetometer logic output versus input to be a function of $B \sin(\theta_B - \theta_0 - \theta_M)$ where θ_0 = Offset Angle.

The hysteresis in the control function is required to reduce power consumption of the scan platform system. It enables the power to be "cut-off" most of the time. If this were not done, the servo would consume power almost equal to that required to overcome coulomb friction when the platform is stationary.

The size of the "dead zone" ($-K_1$ to $+K_1$) and the "hysteresis" zones ($+K_1$ to $+K_2$ and $-K_1$ to $-K_2$) may be arbitrarily controlled by the magnetometer logic circuits. Orbit average power consumption of the platform drive electronics and power dissipation in the scan platform motor windings will be an inverse function of $|K_2 - K_1|$ since this will control the number of start-stop cycles of operation per orbit. The fewer the number of start-stop cycles per orbit, the lower the power consumption.

The difference $K_2 - K_1$ can be any value exceeding a minimum which is a function of the noise in the magnetometer output and the angle which the platform moves after being de-energized.

The alternate control system of Figure 3 may be preferable to implement over that of Figure 2 since the platform position will be controlled to move either side of the magnetometer null input direction.

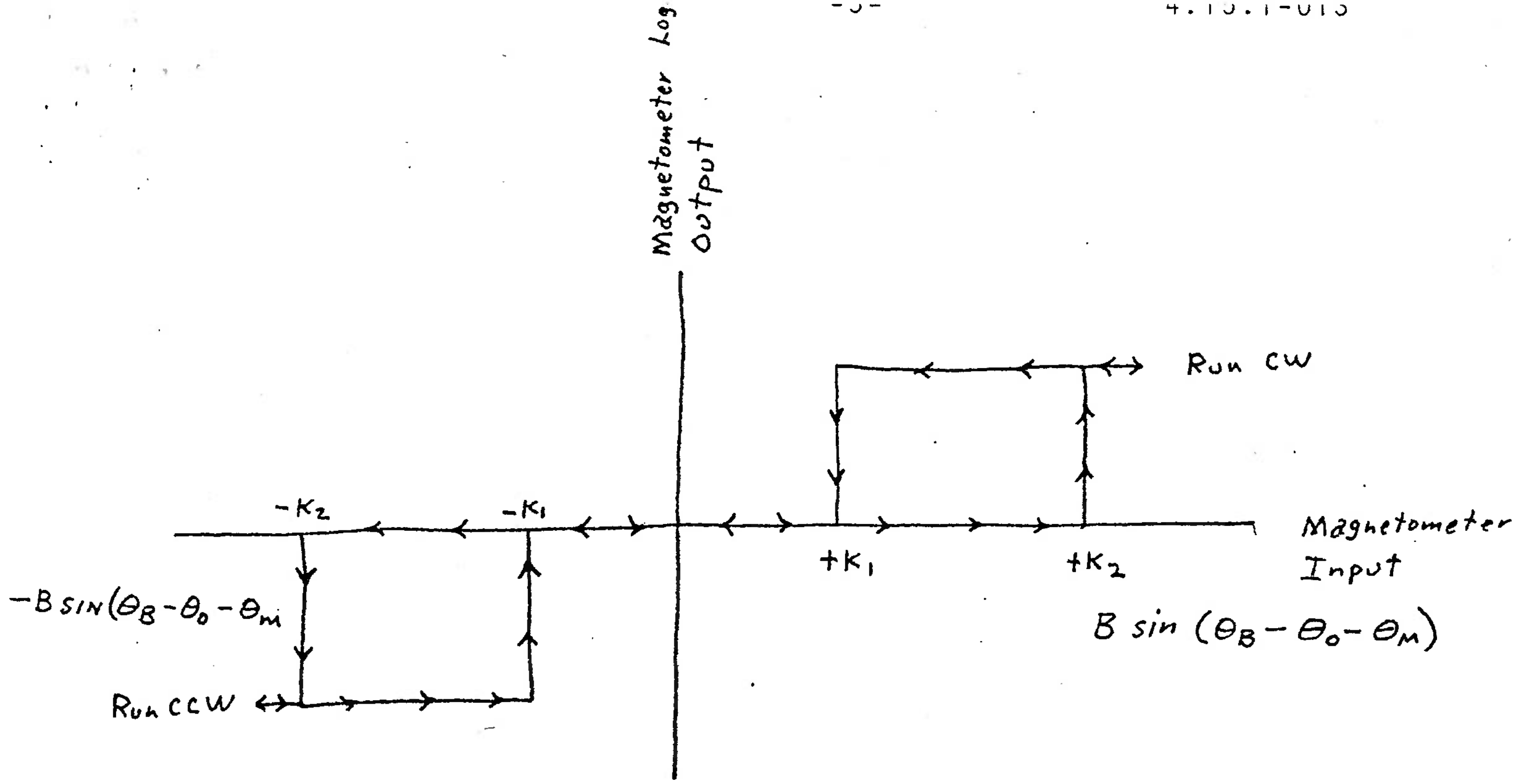

Figure 2(a) - Scan Platform Control Signals versus Magnetometer Input to Orient Fiducial Line in the Parallel to Field Direction

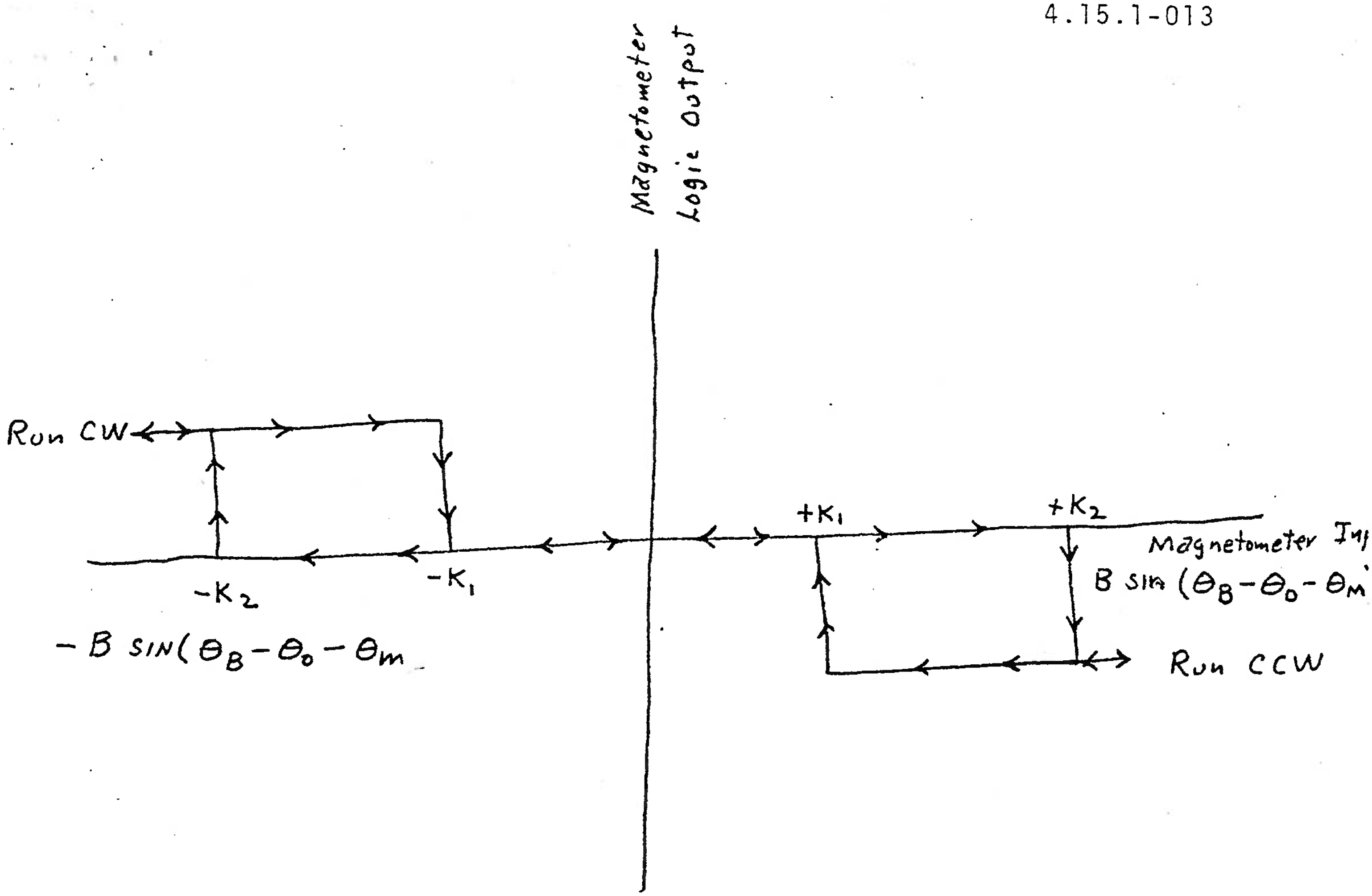

Figure 2(b) - Scan Platform Control Signals versus Magnetometer Input to Orient Fiducial Line in the Anti-Parallel to Field Direction

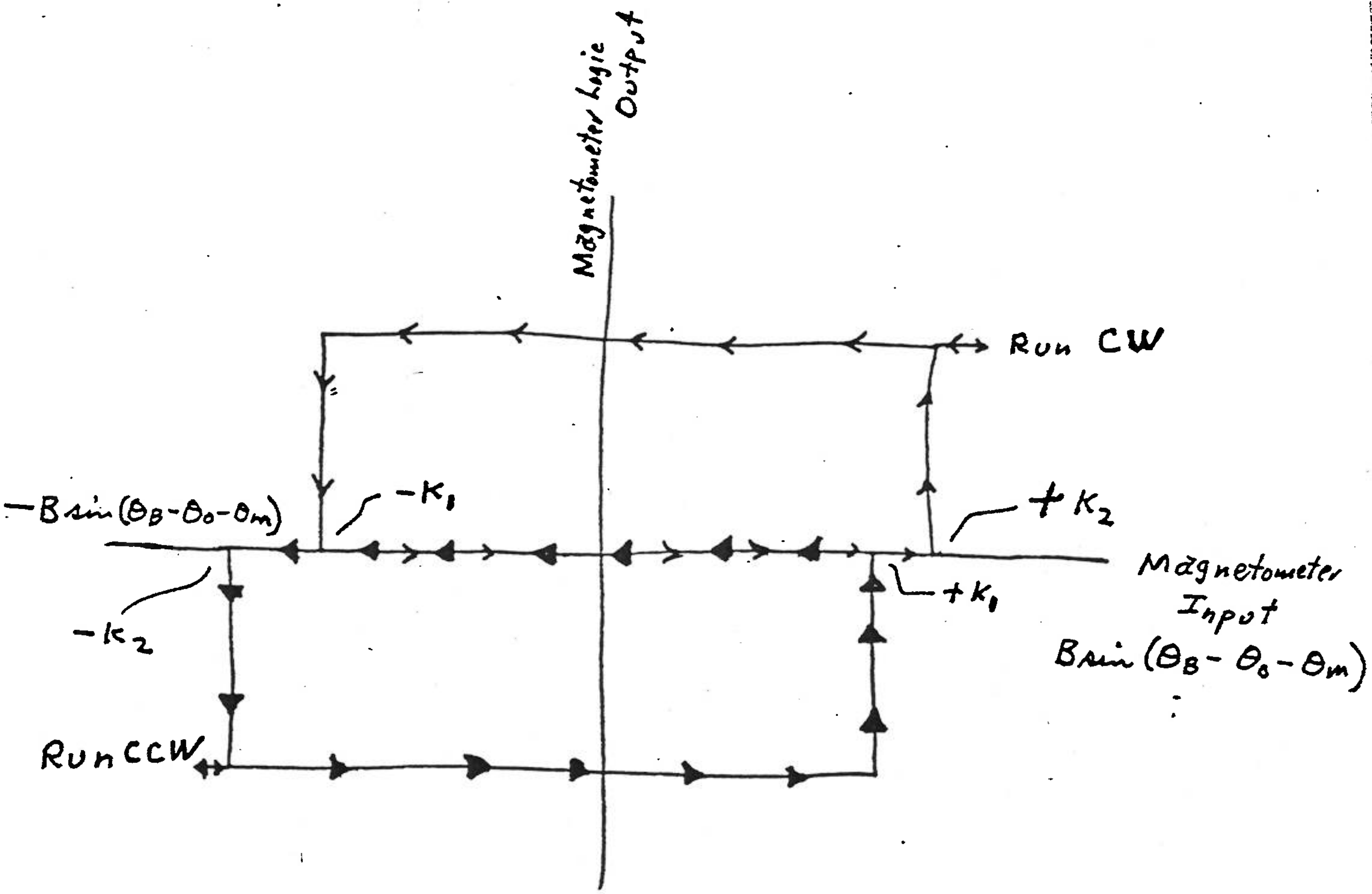

Figure 3. Alternate Double Hysteresis Loop Control Logic

The control systems proposed herein will automatically cause the platform to move in the direction of least amount of rotation to achieve parallel, anti-parallel, or offset pointing relative to the field direction.

Scan Platform Control by Ground Command

The orientation of the scan platform may be controlled by ground command as well as by the earth's magnetic field direction as sensed by the magnetometer. A digital word transmitted to the spacecraft will be used to specify (a) the desired angle between the fiducial line and the +X axis of the spacecraft and (b) the direction of rotation for the platform. Upon receipt of the command, the platform will rotate at a rate of 84.375 degrees per minute in the direction (either clockwise or counter-clockwise) as commanded until the proper orientation is achieved at which time the power to the platform will be automatically shut off, and the platform will coast to a halt within less than 0.1 degree (if coulomb friction is 10 inch-ounces or more for a platform inertia of 50 inch-ounce-sec^2.).

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