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NASA TECH BRIEF

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Temperature Compensation of Digital Inertial Sensors

The problem:

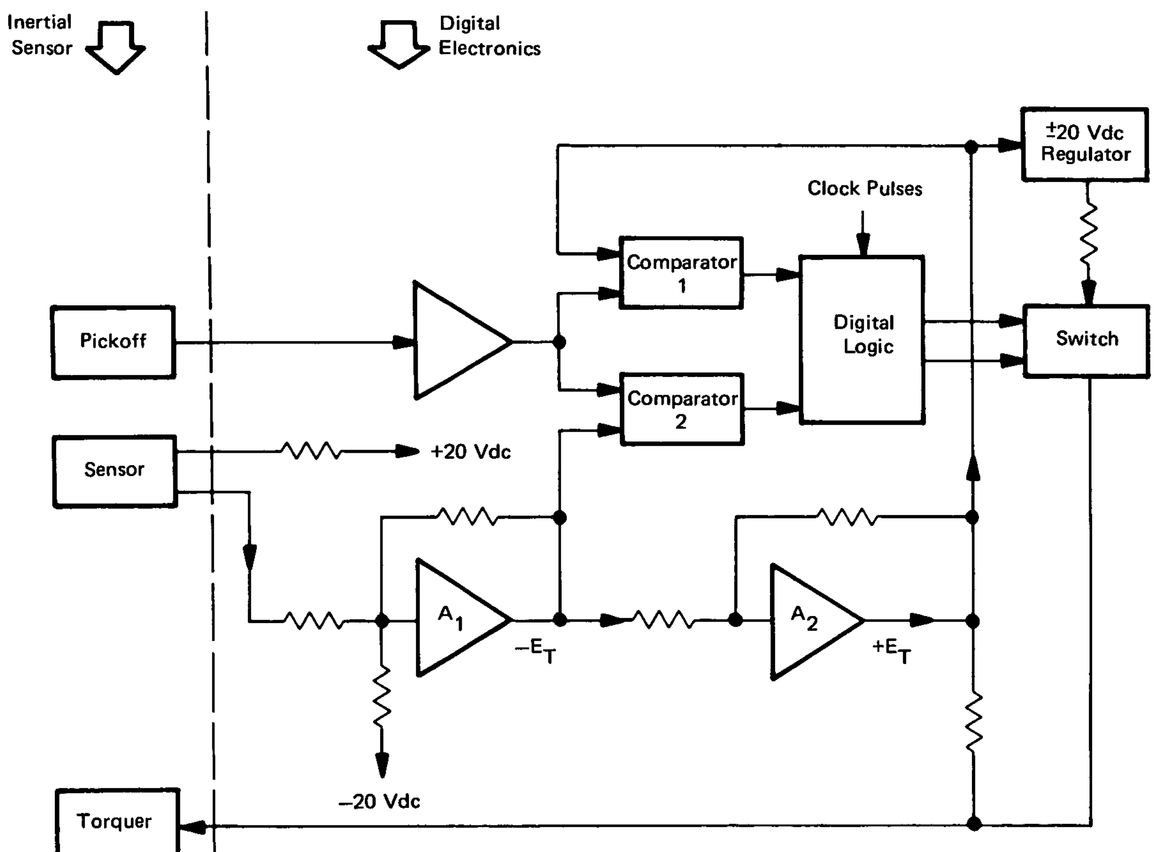
Gyroscopes used as sensors in inertial reference units in aircraft and spacecraft are frequently subjected to large temperature variations from the surrounding environment. These variations cause errors in output as the result of viscosity changes in the flotation fluid, changes in torquer magnet energy, and changes in the fixed gyroscope drift. To minimize these errors, gyroscopes are often supplied with controlled heaters, imposing an extra power demand. Accelerometers also have similar errors and are similarly stabilized.

The solution:

Heaters for thermal stabilization are unnecessary when an analog dc voltage provided by the gyroscope temperature sensor is used to change the outputs to compensate for temperature variations. This sensor is normally installed on all precision gyroscopes.

How it's done:

The approach is illustrated in the digital circuit used to perform a rebalancing function in an inertial reference unit (see figure). One error source in gyroscopes is the



Digital Circuit for Rebalancing

(continued overleaf)

gain variation with temperature. This gain variation is compensated by shifting the trigger levels of the comparators 1 and 2 by means of a temperature dependent dc voltage.

The two comparator reference voltages ($+E_T$ and $-E_T$) are derived from the gyroscope temperature sensor by means of two microcircuit operational amplifiers, A_1 and A_2. A_1 is connected as a summing amplifier. One input to A_1 is the voltage developed across the gyroscope sensor. The other input to A_1 is opposite in polarity and is equal in magnitude to the voltage developed across the sensor. Thus, only the temperature-varying voltage component, which is the difference between the inputs, is amplified. A_2 is a unity-gain inverting amplifier.

A second error source, the reduction of magnet energy with increasing temperature, is corrected as follows. As noted in the block diagram, the current pulse to the gyroscope torquer is obtained through a larger resistor in series with the ±20-Vdc supply and a switch which is controlled by digital logic. The current pulse is made to vary in magnitude by coupling a small portion of $+E_T$ into the ±20-Vdc regulator circuit. The magnitude of this correction is much smaller than that required for gyroscope gain variations. This level reduction is accomplished by a simple resistor divider.

A third error source, the variation of fixed drift (or bias in the case of an accelerometer) with temperature, is corrected by feeding a very small portion of either $+E_T$ or $-E_T$ to the torquer, depending on the direction of the fixed drift change with temperature. The amount of correction required is extremely small for this parameter and is again accomplished by resistor dividers.

Note:

Requests for further information may be directed to:

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Reference: TSP74-10106

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,782,205). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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