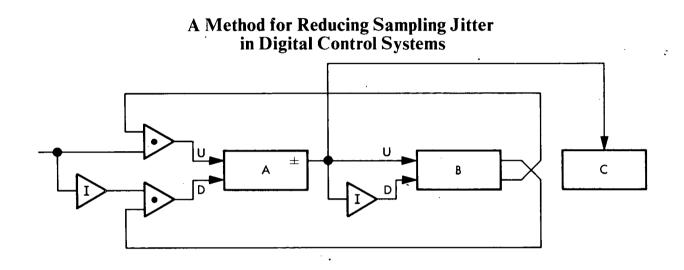
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NASA TECH BRIEF

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The problem:

To design a digital phase lock loop system or bang-bang sampled data system with less hunting, or sampling jitter.

The solution:

Smooth the proportional control with a low pass filter. This method does not significantly affect the loop dynamics when the smoothing filter bandwidth is wide compared to loop bandwidth.

How it's done:

Use a nonlinear filter with two up-down counters and simple logic. The output is two level and the magnitude of the output is lower than the magnitude of the input by a constant factor which depends on the equivalent bandwidth of the nonlinear filter.

Shown above is a block diagram of the digital filter. The basic concept is to keep the integral of the filter output equal to the integral of the input, except for a negligible time delay, while keeping the output amplitude small to reduce the phase jitter. In the example shown, the output is always $\pm 2^{-N}$, compared to the input of 0 or ± 1 . Counter A keeps track of the integral of the input less the integral of the output. Counter B controls the feedback from the output to the input of A by keeping track of the number of outputs of each sign.

During each sampling time when the sign bit of counter A is positive or negative, respectively, the filter output is $+2^{-N}$ or -2^{-N} , and counter B is incremented or decremented. Whenever counter B overflows in the up or down direction, respectively, counter A is decremented or incremented. Since counter B has N stages, the number of up overflows minus the number of down overflows is equal to 2^{N} times the number of positive filter outputs less the number of negative filter outputs. Since the output amplitude is 2^{-N} , the net effect of the feedback from B to A, up to any point in time, is equal to (continued overleaf)

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the integral of the output up to that time, except for a small round off error in counter B. Counter A thus keeps track of the integral of the filter input less the integral of the filter output.

Notes:

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- 1. The advantages of this filter include simplicity of design and low cost of production.
- 2. Documentation is available from:

Clearinghouse for Federal Scientific and Technical Information Springfield, Virginia 22151 Price \$3.00 Reference: TSP69-10338

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, non-exclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: Tage O. Anderson and Dr. William J. Hurd of Caltech/JPL under contract to NASA Pasadena Office (NPO-11088)