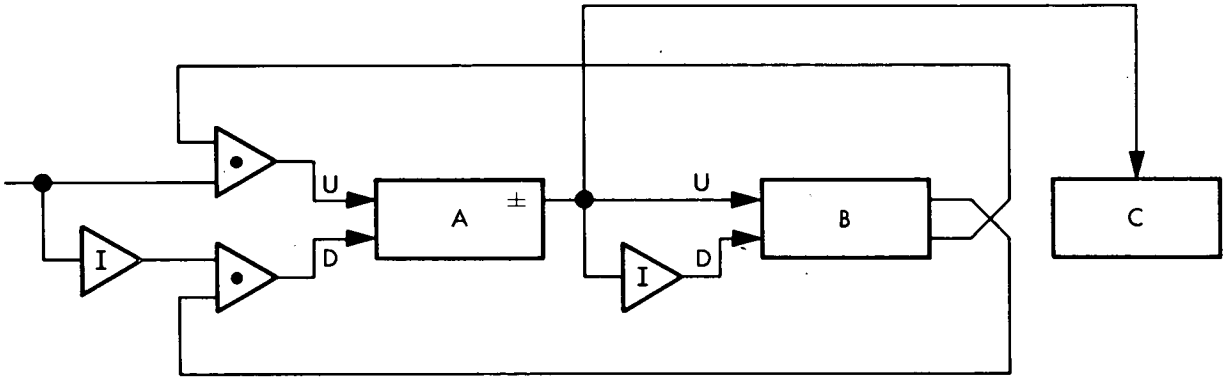
September 1969

Brief 69-10338

NASA TECH BRIEF

A Method for Reducing Sampling Jitter in Digital Control Systems



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)

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:

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:

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