Discussion on: “Transfer Matrices and Advanced Statistical Analysis of Digital Controlled Continuous-Time Periodic Processes with Delay”

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In this paper, the response of a closed-loop sampled-data system $S$ with an finite dimensional linear continuous periodic (FDLCP) process and pure delay to a stationary stochastic input has been studied. This problem formulation is more realistic and allows to take into account the computational delay, which always happens in sampled-data systems.

The paper is well organized and clearly written, but its strong mathematical background and the required preliminaries may cause some problems by reading. For this reason, we would like to summarize the basic idea and main contributions of the paper.

1. The paper develops closed expressions for the parametric transfer matrix (PTM) $W_{yx}(s,t)$ on basis of the results of [1, 2] and by using the stroboscopic property of the sampler.

$$W_{yx}(s,t) = W_{yx}(s,t)G(s) = W_{xf}(s,t)[I_t - W_{xf}(s,0)]^{-1}$$

where

$$W_{xf}(s,t) = e^{-st}e^{-(aT + bT)x}$$

$$\int_0^T \dot{W}_0(T, s, t - \hat{r}_2, \nu + \hat{r}_1)h(\nu)d\nu W_0(s)$$

for $T_1 = aT + bT$, $0 \leq \hat{r}_1 \leq T$, ($i = 1, 2$).

2. The paper investigates the properties of the poles looking to the PTM as a function of the argument $s$.

3. On basis of the properties of the PTM $W_{yx}(s,t)$, the paper provides the solution of the advanced statistical analysis problem of the system $S$.

$$d_y(t) = \tilde{d}_y(t - \hat{r}_2),$$

$$\tilde{d}_y(t) = \frac{1}{2\pi} \oint \text{trace}P(z, t) \frac{dz}{z}$$

where the integration is taken over the unit circle anti-clockwise and $P(z, t) = \frac{1}{\Delta(z)}$.

The problems addressed in the paper are based on the parametric transfer matrix (PTM) theory and an advanced form of statistical analysis. Moreover, a characteristic polynomial is defined, which gives necessary and sufficient conditions for the asymptotic stability of the system $S$. Given the difficulties of computing the parametric transfer matrix (PTM), it is not surprising that the results obtained refer to a special class of closed-loop sampled-data systems. Justification for the study of such particular class lies in the application examples. Although relevant practical problems can be solved using the techniques this paper proposed, the conditions given are not quite necessary and sufficient to design digital controllers and filters at FDLCP processes with pure delay by applying the achieved closed formula for the $H_2$ norm. The
solutions of control problems for more general classes on linear periodic (LP) systems will have to wait for further development of PTM theory, or be based on alternative concepts.

References


Final Comment by the Authors

B.P. Lampe, E.N. Rosenwasser

The mentioned paper is a logic sequel of the paper [1], where the approach represented in [2, 3] has been extended from sampled-data (SD) systems to continuous periodic processes. This approach is connected with applying the parametric transfer matrix (PTM) concept and the stroboscopic effect of the sampler. The comment essentially repeats the basics of the paper content and the obtained results therein.

At the same time the comments concerning the general evaluation of the chosen approach, in our opinion are depreciating, and we do not agree with them.

The author of the discussion wrote that the simple structure, studied in the paper, limits the possibilities of our method, because of problems to calculate the PTM for more complicated systems. In our opinion that apprehension is baseless. The considered structure was chosen only in order to demonstrate the ideas for extending the PTM method from SD systems to continuous periodic elements with several delays. Already the chosen structure meets a number of practical applications. On the other side, in analogy to [2, 3] it can be shown that the argued approach can be extended to systems of arbitrary structure with several periodic elements or several sampling elements. The one and only condition for the possibility of such an extension consists in the postulate that the periods of all non-stationary elements must commensurate. Then, in addition to the solution of the advanced statistical analysis problem, we can find the solution of the $H_2$ and $L_2$ optimization problem.

A detailed consideration of those questions, the development of corresponding software tools, and also the solution of application problems will be the topic of our future research.

References