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Calculation Of Continuous Discrete Systems With Multiple Synchronous Interruptions

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ABSTRACT

This work considers continuous-discrete frameworks with a few quantizers (keys), closing synchronously, but with diverse quantization periods, which are troublesome to analyze. Clearly, at the same time, all those inadequacies of the portrayal of the energetic characteristics of frameworks based on the z-transformation stay, which were pointed out in which they decide the thought of the specified lesson of frameworks from more common positions.

KEYWORDS

Continuous-discrete systems, function, synchronization, object, quantization, dynamics, linear systems, non-stationary, transfer functions.

INTRODUCTION

On the off chance that it is required to decide the deterministic responses of the framework and discrete minutes of time, at that point such an issue can be unraveled by known strategies (see, for illustration, [2, 1962]), in spite of the fact that the calculated relations in this case contrast altogether from the known equations for straightforward discrete frameworks with one quantizing component. Besides, as will be appeared underneath, the calculation equations for the named lesson of frameworks compare to the relations embraced within the investigation of non-stationary frameworks, the device of which is helpful to utilize for describing direct and within the common case non-stationary continuous-discrete frameworks [3, 1978].

THE MAIN PART

The depictions of continuous-discrete joins presented in [3, 1978] are utilized underneath to get express explanatory connections that decide the energetic characteristics – bi-frequency exchange capacities and "input-output" associations in direct frameworks with two or more synchronous interrupts.

Let us to begin with depict the joins for expanding the clock recurrence bringing down, normal for this lesson of frameworks. These joins characterize direct changes of input signals, and they can be considered as straight objects with suitable exchange capacities.

The step down interface could be a switch that closes with a recurrence that's times less than the recurrence of the input signal.

The change weighting work is portrayed by the work.

$$\Delta(kn-m)=\begin{cases}1, npu & m=kn\\ 0, npu & m\neq kn\end{cases}$$

Let us calculate, in accordance with the definition [3, 1978], the bi-frequency transfer function $\Gamma(z_2, z_1)$ of this link

$$\Gamma(z_2,z_1)=\frac{1}{z_1}\sum_{n=0}^{\infty}\sum_{m=0}^{nk} z_z^{-n} z_1^{m}\Delta(nk-m). \qquad (2)$$

Performing the summation, we find

$$\Gamma(z_2,z_1)=\frac{z_2}{z_1}\frac{1}{z_2-z_1^k} \qquad (3)$$

Let's take note. That the found bi-frequency exchange work is the bit of the necessarily equation (24) on page 552 in [2, 1962]. In other words, when depicting circuits of a more complex nature than the only discrete frameworks, it isn't conceivable to utilize basic logarithmic change equations, and endeavors to overcome the troubles emerging in this case lead to relations commonplace for depicting nonstationary straight frameworks utilizing the device of bi-frequency exchange capacities.

An express expression for the picture of the reaction at the yield of the step-down connect is gotten by composing the regular equation for the relationship between the connect input and yield

$$X(z)=\frac{1}{2\pi j}\oint\frac{z}{\eta}\frac{1}{Z-\eta^k}g(\eta)d(\eta). \qquad (4)$$

Here $g(\eta)$ -image of the signal at the input of the link. The form of integration isolates the highlights of the capacities $g\frac{(\eta)}{\eta}$ and $\left(z-\eta^{k}\right)^{-1}$. Since the shafts $g(\eta)$ are obscure, we are going coordinated utilizing the buildups at the posts η_m of the known work $\left(z-\eta^{k}\right)^{-1}$

$$y(\eta)=\Gamma(z,\eta)g(\eta)=\frac{P(\eta)}{Q(\eta)} \qquad (6)$$

The residue at the m -th pole is found by the well-known formula [4, 1966]

$$\underline{\operatorname{Re} s_{\eta=\eta_m} y(\eta)}=\left[\frac{P(\eta)}{Q(\eta)}\right]_{\eta=\eta_m} \qquad (7)$$

Here $Q(\eta)=Z-\eta^{k}$, $\quad P(\eta)=Zg\frac{(\eta)}{\eta}$.

Summing up the buildups and taking under consideration the heading of navigating the form, we get the well-known equation [2, 1962], which, in any case, is concluded in a easier way

$$x(z)=\frac{1}{k}\sum_{m=0}^{k-1} g(z^{\frac{1}{k}}e^{j\frac{2\pi}{k}m}) \qquad (8)$$

At the same time, the calculation of $x(z)$ utilizing the final equation is troublesome at $k\geq 3.$. In commonsense calculations, it is simpler to coordinated with the known expression $g(\eta)$ utilizing the buildups at the posts $g\frac{(\eta)}{\eta}$ (see example) to discover the response picture. Let us presently portray the step for expanding the beat. It is replied by a key, which closes synchronously with the clock minutes, but with a recurrence that's k times higher. The comparing weighting work is the delta work $\Delta(n-km)$. The bi-frequency exchange work of this connect calculated by definition [3, 1978] is

$$\Gamma(z_2,z_1)=\frac{1}{z_1}\frac{z_2^{k}}{z_2^{k}-z_1}. \qquad (9)$$

If a signal with an image $g(z)$ arrives at the input of this link, then for the image of the signal at the output, we obtain the ratio

$$x(z_2) = \frac{1}{2\pi j} \oint \frac{1}{z_1} \frac{z_2^k}{z_2^k - z_1} g(z_1) dz_1 = g(z_2^k) \qquad (10)$$

For advance introduction, we require the characteristics of a serial association of energetic continuous-discrete joins and keys that alter the quantization frequency. Let us calculate the exchange work of a normal serial association comprising of a key that closes with a period of and a nonstop portion that incorporates an extrapolator, at the input of which discrete signals with a period of is received, and a stationary ceaseless interface. The bi-frequency exchange capacities of the key and extrapolator were gotten in [3, 1978].

$$\Gamma_k(z,s) = \frac{z}{z - e^{s\tau_2}},$$

$$\Gamma_k(z,s) = \frac{W_1(s)}{z(1 - ze^{-s\tau_1})},.$$

Here, $W_1(1)$ denotes the usual transfer function of the extrapolator and the continuous stationary part. In accordance with the general formula [3, 1978] for the sequential connection of links 1 and 2 (Fig. 1), we have

$$\Gamma_1(z_2, z_1) = \frac{1}{2\pi j} \int_{c-j\infty}^{c+j\infty} \frac{z_2}{z_1 - e^{s\tau_2}} \frac{W_1(s)}{z_1(1 - z_1 e^{-s\tau_1})} ds. \qquad (11)$$

To streamline the integration, we pass over the variable Z_2,, to the Laplace diskette change, supplanting Z_2, with $e^{s_2\tau_2}$ and coordinated utilizing the buildups at the straightforward shafts

$$s = s_2 + j\frac{2\pi}{\tau_2}m, \qquad m = 0, \pm1, \pm2, \ldots$$

Summing up the residues, for the required transfer function we obtain the following relation

$$\Gamma_1(s_2, z_1) = \frac{1}{z_1\tau_2} \sum_{m=-\infty}^{\infty} \frac{W_1(s_2 + j\frac{2\pi}{\tau_2}m)}{1 - z_1 e^{-s_2\tau_1 - j\frac{2\pi}{\tau_2}\tau_1 m}} \qquad (12)$$

In particular, for $\tau_1 = \tau_2 = \tau$

$$\Gamma_1(s_2 z_1) = \frac{1}{1 - z_1 e^{-s_2\tau}} \frac{1}{z_1\tau} \sum_{m=-\infty}^{\infty} W_1(s_2 + j\frac{2\pi}{\tau}m). \qquad (13)$$

Note that an infinite sum with a coefficient of $\frac{1}{\tau}$ is a discrete Laplace transform $W(z_2)$, corresponding to a continuous image $W(s_2)$,.

$$W_1(z_2) = \frac{1}{\tau}\sum_{m_n=-\infty}^{\infty} W_1(s_2 + j\frac{2\pi}{\tau}m), \quad z_2 = e^{s_2\tau} \tag{14}$$

Passing again to the z transformation with respect to the variable, we find

$$\Gamma_1(z_2, z_1) = W_1(z_2)\frac{z_2}{z_1(z_2 - z_1)} \tag{15}$$

From the last mentioned it is simple to conclude that the combination of the extrapolator and the key comes about within the indistinguishable change. Without a doubt, since for the capacity component the extrapolator is $W_1(z) = 1$, at that point beneath this condition we get from (15)

$$\Gamma_1(z_2, z_1) = \frac{z_2}{z_1(z_2 - z_1)}, \tag{16}$$

which corresponds to the identical transformation.

Now let $\tau_1 = k\tau_2$, the switch at the output is closed with a frequency K times greater than the quantization frequency of the input action. Then

$$\Gamma_1(s_2, z_1) = \frac{1}{z_1\tau_2}\sum_{m=-\infty}^{\infty}\frac{W_2(s_2 + j\frac{2\pi}{\tau_2}m)}{1 - z_1 e^{-s_2\tau_1}} \tag{17}$$

Or taking into account (14), we find

$$\Gamma_1(z_2, z_1) = \frac{1}{z_1}\frac{W_1(z_2)}{1 - z_1\ z_2^{-k}}. \tag{18}$$

It is somewhat more difficult to consider the case when $\tau_2 = k\tau_1$. In this case, from (12) we have (Fig. 1b)

$$\Gamma_2(s_2, z_1) = \frac{1}{z_1 k\tau_1} \sum_{m=-\infty}^{\infty} \frac{W_2(s_2 + j\frac{2\pi}{k\tau_1}m)}{1 - z_1 e^{-(s_2\tau_1 + j\frac{2\pi}{k}m}}. \quad (19)$$

Let us use the formula to change the order of summation

$$\sum_{m=-\infty}^{\infty} a_m = \sum_{i=0}^{k-1} \sum_{l=-\infty}^{\infty} a_{i+kl} \quad (20)$$

and rewrite expression (19) in the form

$$\Gamma_2(s_2, z_1) = \frac{1}{z_1 k\tau_1} \sum_{i=0}^{k-1} \sum_{l=-\infty}^{\infty} \frac{W_2(s_2 + j\frac{2\pi}{k\tau_1}(i + kl))}{1 - z_1 e^{-(s_2\tau_1 + j\frac{2\pi}{k}(i+kl))}}. \quad (21)$$

Taking into account the connection between continuous and discrete Laplace transforms, we find

$$\Gamma_2(s_2, z_1) = \frac{1}{z_1 k} \sum_{i=0}^{k-1} \frac{W_2(e^{s_2\tau_1 + j\frac{2\pi}{k}i})}{1 - z_1 e^{-(s_2\tau_1 + j\frac{2\pi}{k}i}}. \quad (22)$$

Passing to the *z*-transformation with respect to the variable, we obtain the desired transfer function

$$\Gamma_2(z_2, z_1) = \frac{1}{z_1 k} \sum_{i=0}^{k-1} \frac{W_2(z_2^{\frac{1}{k}} e^{j\frac{2\pi}{k}i})}{1 - z_1 z_2^{-\frac{1}{k}} e^{-j\frac{2\pi}{k}i}}. \quad (23)$$

When calculating the exchange capacities of open frameworks composed of joins decided by equations (18) and (23), the exchange work of the arrangement association of such joins (Fig. 1) is break even with to

$$\Gamma_P(z_2, z_1) = \frac{1}{2\pi j} \varnothing \frac{1}{zk} \sum_{i=0}^{k-1} \frac{W_2(z_2^{\frac{1}{k}} e^{j\frac{2\pi}{k}i})}{1 - z\, z_2^{-\frac{1}{k}} e^{-j\frac{2\pi}{k}i}} \cdot \frac{1}{z_1} \frac{W_1(z)}{1 - z_1\, z^{-k}}. \quad (24)$$

Integrating with deductions in simple stripes

$$Z = Z_2^{\frac{1}{k}} e^{j\frac{2\pi}{k}i}, \quad i = 0,1,\ldots..,k-1$$

Let us find an explicit expression for $\Gamma_p(z_2, z_1)$

$$\Gamma_p(z_2, z_1) = \frac{z_2}{z_1(z_2 - z_1)} \frac{1}{k} \sum_{i=0}^{k-1} W_2(z_2^{\frac{1}{k}} e^{j\frac{2\pi}{k}i}) W_1(z_2^{\frac{1}{k}} e^{j\frac{2\pi}{k}i}) \quad (25)$$

As noted in [3, 1978], to get the exchange capacities of closed frameworks, it is vital to discover an express expression for the reverse administrator $[1 + \Gamma_p(z_2, z_1)]^{-1}$. It is straightforwardly confirmed that the comparing exchange work of the shown converse administrator is composed within the taking after frame

$$\Gamma(z_2, z_1) = \frac{z_2}{z_1(z_2 - z_1)}[1 + \frac{1}{k}\sum_{i=0}^{k-1} W_2(z_2 e^{j\frac{2\pi}{k}i}) W_1(z_2^{\frac{1}{k}} e^{j\frac{2\pi}{k}i})]^{-1} \quad (26)$$

RESULTS AND DISCUSSIONS

Example: Consider the framework appeared in Fig. which in [1, 1971] was analyzed utilizing state space methods. Let's calculate the nonstop reaction of the framework with regard to the TTT variable to a single step activity. In our case

$$W_1(s) = \frac{1 - e^{-\tau s}}{s^2}, \qquad W_1(z) = \frac{\tau}{z - 1},$$

$$W_2(s) = \frac{1 - e^{-3\tau s}}{2s(s+1)}, \qquad W_2(z) = \frac{(1-d)(z^2 + z + 1)}{2z^2(z - d)}, d = e^{-\tau}.$$

The transfer function of an open-loop system, as noted above, is conveniently calculated not by the explicit formula (25), but by means of residues by a formula similar to relation (4).

$$\Gamma_p(z_2, z_1) = \frac{z_2}{z_1(z_2 - z_1)} \frac{1}{2\pi j} \oint \frac{\tau(1-d)(\eta^2 + \eta + 1)}{2\eta^3(\eta - 1)(\eta - d)(z_2 - \eta^3)} d\eta.$$

We will integrate by means of residues at straightforward shafts $\eta = 1, \eta = d$ and a post of multiplicity 3 $\eta = 0,$. Making calculations and we are going, to begin with, discovering the character of the open-loop framework

$$\Gamma_p(z_2, z_1) = \frac{z_2}{z_1(z_2 - z_1)} \frac{0{,}129 z_2 + 0{,}188}{z_2^2 - 1{,}366 z_2 + 0{,}366} d\eta.$$

And then the transfer function of the closed system by mistake

$$\Gamma_e(z_2, z_1) = \frac{z_2}{z_1(z_2 - z_1)} \frac{z_2^2 - 1{,}366 z_2 + 0{,}366}{z_2^2 - 1{,}237 z_2 + 0{,}554}.$$

Using the transfer function associating the system error with coordinate $x(t)$

$$\Gamma_2(s_2, z_1) = \frac{1 - e^{-s}}{2s(s+1)z(1 - ze^{-s})}.$$

And found above $\Gamma_e(z_2, z_1)$ according to the formula of serial connection, we find the desired transfer function connecting images $x(s)$ and $g(z)$

$$\Gamma(z_2, z_1) = \frac{1 - e^{-s}}{2sz\ (s+1)(1 - ze^{-s})} \frac{1 - 1{,}366 e^{-s} + 0{,}366 e^{-2s}}{1 - 1{,}237 e^{-s} + 0{,}554 e^{-2s}}.$$

CONCLUSION

Finally, using the input-output relationship formula, we find the image of the continuous response of the system to a single step action

$$x(s) = \frac{1}{2s(s+1)} \frac{1 - 1{,}366 e^{-s} + 0{,}366 e^{-2s}}{1 - 1{,}237 e^{-s} + 0{,}554 e^{-2s}}.$$

The found proportions, in conjunction with the introductory portrayals of the joins of the framework, make it conceivable to get express explanatory dependences of input-output between any focuses of the framework, notwithstanding of the sort of the comparing signals, and, on their premise, to calculate the reactions beneath deterministic and arbitrary impacts.

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