The second problem the reader faces is the &ldquo;onion skin&rdquo; nature of the document. The &ldquo;onion skin&rdquo; syntax is a style of writing that is similar to the way an onion is peeled. The outer layers are removed one by one, revealing the inner layers. This makes it difficult to understand the document as a whole. In this particular document, the &ldquo;onion skin&rdquo; syntax is used to create a sense of mystery and intrigue, but it also makes it difficult to follow the argument. The reader must work hard to piece together the different layers of information, and it is easy to get lost along the way. It is also possible that the &ldquo;onion skin&rdquo; syntax is used to create a sense of ambiguity, as the reader is not sure what is being said. This can make the document difficult to understand, but it also adds to the sense of mystery and intrigue. Overall, the &ldquo;onion skin&rdquo; syntax is a challenging but rewarding read. It requires careful attention and patience, but it is ultimately worth the effort. The reader is rewarded with a deeper understanding of the topic, and a sense of satisfaction at having overcome the challenge.
...
In the context of fluid mechanics, the Navier-Stokes equations are often used to model the dynamics of fluid flow. These equations are a set of partial differential equations that describe the motion of viscous fluids.

\[ \begin{align*}
\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla) \mathbf{u} &= -\nabla p + \mu \nabla^2 \mathbf{u} + \mathbf{f} \\
\nabla \cdot \mathbf{u} &= 0
\end{align*} \]

Here, \( \mathbf{u} \) is the velocity field, \( p \) is the pressure, \( \mu \) is the dynamic viscosity of the fluid, and \( \mathbf{f} \) represents external forces acting on the fluid.

The solution to these equations can be obtained using various numerical methods, such as finite difference, finite element, or spectral methods. These methods allow for the simulation of fluid dynamics in complex geometries and under various conditions.
Theorem 4. Let $A = \{a \in \mathbb{R} \mid a > 0 \}$ and $b \in \mathbb{R}$. Then, the following statements are equivalent:

1. $a > 0$ and $b > 0$.
2. $a + b = (a - b)^2$.

Proof of Theorem 4.

Let's assume that $a > 0$ and $b > 0$. Then, we can write:

$$a + b = (a - b)^2 = a^2 - 2ab + b^2.$$

Subtracting $a^2$ from both sides, we get:

$$b = a^2 - 2ab + b^2 - a^2 = b^2 - 2ab.$$

Adding $2ab$ to both sides, we obtain:

$$b + 2ab = b^2.$$

Factoring out $b$, we have:

$$b(1 + 2a) = b^2.$$

Since $b > 0$, we can divide both sides by $b$ to get:

$$1 + 2a = b.$$

Hence, we have shown that $a + b = (a - b)^2$ if $a > 0$ and $b > 0$. The converse can be proved similarly.
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\[
\begin{align*}
(p(x))^x &= ((x)^y)^x = (x)^{xy} \\
\therefore p(x)^x &= x^{xy} \\
\end{align*}
\]
and $y$. Since each block of $C(s)$ and $P_h(s)$ denotes a canonical realization, the closed-loop system is internally exponentially stable by Theorem 5.

**Remark 2.** Note that in Theorem 7 above, we take the canonical realization of $P_h$ in the perturbed system, and not the parallel connection of canonical realizations of $P$ and $\Delta$. The latter may be non-canonical due to possible pole-zero cancellation between $P$ and $\Delta$. In reality, one is given a nominal model, and an unknown plant whose distance from the nominal model is unknown but bounded by $r(\omega)$, so it is more natural to take the canonical realization of this unknown plant (as far as we stay within canonical realizations), rather than considering a separate realization for $\Delta(s)$. Thus we write $P_h = P + \Delta$ only for transfer matrices, but not for realizations. But this does not cause any problem since the expression $P_h = P + \Delta$ is used only for showing that the closed-loop transfer matrix is in $H^\infty$.

**Remark 3.** We also remark that if

$$\sigma_{\max}(r(\omega)C(\omega)(I + P(\omega) C(\omega)^{-1})) \approx 1 \quad (21)$$

for some $\omega$, then there exists a rational (hence in class $\mathcal{R}$) destabilizing $\Delta(s)$ in the class of perturbations given by (18). This can be shown using similar arguments as Chen and Desoer (1982).

As an application, let us give the following example.

**Example 2 (Repetitive control system).** Consider the modified repetitive control system given by Fig. 4 (Hara et al., 1988). The first block $1/(1 - f(s)e^{-Ls})$ is a repetitive compensator, and the second block $C(s)$ is a stabilizing compensator. We assume that $P$ and $C$ belong to class $\mathcal{R}$ and satisfies condition (i) of Theorem 7. (Typically, they are rational, and $P$ is strictly proper.) Also, $f(s)$ is a rational, strictly proper, stable transfer function. Hence the repetitive control block $1/(1 - f(s)e^{-Ls})$ is itself a retarded delay-differential system, so it also belongs to class $\mathcal{R}$. This system is known to have a very high tracking ability for periodic signals of a fixed period $L$, and has been utilized in many practical systems, e.g., control of proton-synchrotron magnet power supply, learning control scheme for robot manipulators, etc. [see, e.g., Hara et al. (1988) for details].

Let us examine the robust stability of this system.

Assume the following two conditions:

(i) \[ \|f(s)(I + PC)^{-1}\|_\infty < \gamma < 1, \]

(ii) \[ (I + PC)^{-1} - PI^{-1}(1 + CP)^{-1} \in H^\infty(\mathcal{R}). \]

Under these conditions, the nominal system Fig. 4 without the perturbation $\Delta$ is stable. Indeed, as in the same way in the proof of Theorem 7, we have an equivalent diagram Fig. 5 for the nominal system. Since $(I + PC)^{-1}$ and $(I + PC)^{-1}P$ are in $H^\infty$, and \[ \|f(s)(I + PC)^{-1}\|_\infty < 1 \]

by our hypotheses, the closed-loop system Fig. 5 is internally stable by Theorem 6.

Let us now analyze the robust stability of this system. Suppose that the unknown perturbation $\Delta(s)$ satisfies the frequency-domain bound

$$|\Delta(s)| < \|r(\omega)| \quad \text{for all } \omega.$$}

for some $H^\infty$-function $r(s)$. Then our robust stability condition (19) becomes

$$\|f(s)(I + PC)^{-1} - PI^{-1}(1 + CP)^{-1}\| < 1$$

where $r(s)$ is the bound for perturbations $\Delta(s)$ as above. Now we have

$$C(1 - f(s)e^{-Ls})^{-1} = (I + PC)^{-1}(I - f(s)e^{-Ls}(I + PC)^{-1})^{-1}.$$

Note also that

$$\|f(s)(I + PC)^{-1}\| = \sum_{n=0}^{\infty} \|e^{-Ls}f(s)(I + PC)^{-1}\|_n = 1 + \gamma + \gamma^2 + \cdots = \frac{1}{1 - \gamma}.$$