

Minimum phase definition

Wrong. The poles must be inside the unit circle for the system to be both causal and stable. It is the zeros that can be inside or outside the unit circle. If some zeros are outside the unit circle and some are inside, one speaks of a "mixed phase" system. If all the zeros are outside the unit circle, one speaks of a "maximum phase" system.

> But what does it mean?

The minimum phase property has to do with time delays in the impulse response. Minimum phase systems have an impulse response where the energy is concentrated at an as early time as possible.

> What problem does it cause in terms of non-minimum phase?

Well, minimum phase systems are easy to handle from a mathematical point of view. Since all the zeros are inside the unit circle, the inverse filter is stable. One can do certain things with minimum phase systems that one can not do with mixed phase systems.

If the system one investigates is not minimum phase, one must be very careful with how one conducts the analysis. The "easy" system identification methods are based on the assumption of minimum phase. If it's sufficient to describe the system in terms of the Power Spectral Density, PDF, of its transfer function, minimum phase techniques are often good enough regardless of whether the system actually is minimum phase, or not.

If you need to estimate the time-domain impulse response from a frequency domain measurement, you might find yourself in big trouble if you are only able to estimate the PDF, which does not preserve the phase response of the system.

You can estimate the minimum phase impulse response from a PDF. You can not estimate mixed phase impulse responses from a PDF. So if you estimate a minimum phase impulse response for a system that actually is mixed phase, you make a mistake which may or may not be important. It depends on the application.

> Spectral Density, PDF, ...

"PDF" --> probability density function. The identity isn't obvious.

If we consider a simple stable, 1-st order, low-pass, system $(s-z)/(s+p)$ (with z and p positive), with an "unstable" zero, i.e. in the right half s plane, or outside the unit disk in the Z domain, then physically, it translates into a system with an initial response which is in the opposite direction of the applied stimulus, and of its long term response (ex. to a step input). A practical example which helps to see this, is in handling a long flexible stick, or beam. A simple, crude approximation would consist of two rigid sticks, joined by some elastic, flexible, spring-like, coupling. If one holds one stick at one end, and applies some torque to change the angular orientation of the overall stick, the other end will inevitably, initially (i.e. at $t=0+$), turn in the opposite direction. We can then see how this will add to the overall response time, or phase delay in the frequency

response. A "stable" zero, on the other hand, ex. $(s+z)/(s+p)$, which effectively adds an anticipative component to the response (the purpose of P in PID-based control), serves to reduce the overall response time, precisely because of it's anticipative character. Such "intuitive" characterization of otherwise technical terminology hopefully serves to get a better "feel" for what's really going on in a system and it's sub-components, and therefore how to better control it.