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Preliminaries (to refresh dormant neurons)

- A system is *linear* if superposition holds.
 - Scaling of a single input is included.
 - Impulse response yields sufficient information to deduce the response to an arbitrary input.
 - All real systems can be driven into nonlinearity.
 - Linearity only holds over limited range.
- A system is *time-invariant* if time-shifting an input *only* time-shifts the output.
- If a system is LTI, then excitation at f produces steady-state response only at f .

Before we start the analysis, it is good idea to have a review on some of the signal and system fundamentals. Let's start with linear system in which a linear system hold the superposition for the multiple inputs applied to the system; the output of linear system is scaled with the input amplitude. More importantly, Impulse response yields sufficient information to deduce the response to an arbitrary input. Although all the real systems can be driven to the non-linear region, however linearity can be applied for the limited range and model the system as a linear system for that particular region. A system is considered time-invariant If any time shift at the input signal cause only the same time shift at the output signal. If a system is LTI (Linear Time Invariant), then excitation at frequency of f produces steady-state response only at the same frequency. In the other words a LTI system can't generate frequencies other than those frequencies are applied at the input.

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Preliminaries

- If a system is LTV, excitation at f can produce steady-state response at other than f .
 - Superposition holds, so impulse response *still* tells us about response to any other input.
- If a system is nonlinear, excitation at f can also produce response at other than f .
 - Superposition doesn't hold; impulse response cannot be used to infer response to arbitrary excitations.

On the other hand for a LTV (Linear time variant) system, excitation at frequency of f can produce steady-state response at frequencies other than f . Like LTI system, superposition holds, so impulse response still tells us about response to any other input. Considering a non-linear system, the excitation at a frequency f can also produce response at frequencies other than f . As an example a non-linear system can produce harmonics of the frequency at $2f$, $3f$ and etc. However the impulse response of a non-linear system cannot be used to predict the output for any arbitrary input; In the other words unlike LTI system, superposition doesn't hold in a non-linear system.