1. System Response Methods
2. Frequency Response Method
3. Correlation Method
   1. Correlation Functions
      1. Autocorrelation Function

* Time average of Autocorrelation Function
* Properties of auto correlations



1. If u(t) is periodic, then is periodic
   * 1. White Noise Sequence



* auto-correlation of Definition of white noise



* + 1. Cross-correlation Function
* Definition

As time average

In discrete case



* 1. Wiener-Hopf Relationship
     1. Wiener-Hopf Equation
* The in/out cross correlation

Hence

* + 1. Impulse Response Identification Using Wiener-Hopf Equation
* Exm. 4.3: **Impulse response identification**

For asymptotically stable systems, it suffices to determine only **the first elements of ,** so that

* Inputs, and output: , and .After removal of the initial conditions effect, , and
* In/out correlation matrix
* Remember



* + 1. Random Binary Sequences
* Motivation: Diagonal matrix of

If the input is selected as

Then is a diagonal matrix, which is simple to get as

The problem is how to select a signal as (4.2.3.a)

* Method 1: white noise

See (4.6). But not realizable since

- vary large input

- not genuine random noise.

* Method 2: Random Binary Sequence(RBS)
  + 1. Filter properties of Wiener-Hopf Relationship
* Motivation: Why Correlation method rather than pulse response identification?
* If u(t) is a pulse input, we may get .

But due to measurement noise, the output is corrupted by the noise.

Objective: To cancel the noise

* Method
* The correlation method may filter the output measurement. See the following.

Then

If is uncorrelated, , then

* Correlation method(Wiener-Hopf Relation) will filter out the measurement noise.
  1. Frequency Analysis Using Correlation Techniques
     1. Cross-correlation Between Input-output Sine Waves
* Motivation

The previous Method in frequency domain, sampled input of , a fixed the output is

To get the , hence from . measure and corresponding to , is difficult to get in the graph. We need to cancel to the effect of .

1. Let the input / output be

Multiply the output by the and , denote the result as

where sample time, N : # of sampling

1. Sin term

If and has no component of the input frequency,

1. Cos term
   * 1. Transfer-function Estimate Using Correlation Techniques

From the previous calculations, the estimate of is

* *Comment*

In signal processing, this method as Quadrature Modulation. It is especially to be useful to measure the phase difference, which is related to estimate the delay time between the transmit and the received signals.

You may remember to measure the distance an object remotely, QM method is an alternative method.

* 1. Spectral Analysis
     1. Power Spectra
* Definition: Power(auto) spectrum / cross -spectrum
* Power(auto) spectrum = Fourier transform of auto correlation
* Properties
* Power spectrum:
* Nomenclature:

Co spectrum = Real part of

Quadrature spectrum = Imaginary part of

* Quadrature
* In signal processing: Let signal Then the quadrature signal of , is
  + 1. Transfer-function Estimate Using Power Spectra
* Transfer Function Relation

Hence

* If the output is corrupted by noise, then is corrupted by the noise spectrum. (Think of in the time domain case). Hence it is needed to cancel out the noise effect.
  + 1. (Skip) Bias-variance tradeoff in transfer-function Estimates