Noise in Communication Systems (Lectures 4 & 5)

- Sources of Noise
- Statistical Properties of Noise
  - PDF
  - PSD

- Noise Calculations
  - Noise Figure
  - Gaussian Noise
  - Intermodulation Products
  - Multiple Uncorrelated Noise Sources
Noise Analysis

Uncorrelated Noise

Present regardless of whether a signal is present or not.

E.g. \( R(t) = S(t) + N(t) \)

Signal \( \uparrow \) \( \uparrow \) Noise

Correlated Noise

Noise that is correlated (mutually related) to the signal and cannot be present unless there is a signal present.

E.g. \( R(t) = S(t) + f(S(t)) \) \( \overline{\text{Noise}} \)
UNCOMPLETED NOISE SOURCES

EXTERNAL

• Atmospheric
• Extraterrestrial
• Solar
• Cosmic
• Man-Made
• Interference (OTHER SIGNALS)

INTERNAL

• Thermal
• Shot
• Transient
• Time

Solar
• Solar wind from the Sun's heat
• Solar flares
• Cosmic noise
• Man-made interference (OTHER SIGNALS)

Interference
External Noise — Noise generated outside a circuit or system.

- Atmospherics — Occurs in the Earth's atmosphere
  - "Static electricity"
  - Sputtering crackling in a radio

- External Interstellar — Electrical signals outside the Earth's atmosphere
  - "Deep space noise"
  - Generated from the Sun's heat, constant int. la. solar flare

- Solar —

- Cosmic — From sources throughout the galaxies
  - Often called black-body noise

- Man-Made —
  - Electric motors
  - Ignition systems
  - Industrial noise machines

- Interference — Other signals or harmonics of other signals
  - Beat frequencies
INTERNAL NOISE

SHOT NOISE - Random arrival of carriers (h's & e's) at the output of an electronic device. Current not steady because distance carriers travel from I to O vary.

TRANSIT TIME NOISE
random variation in the time it takes for a carrier to propagate through a device. When prop. time is appreciable part of a cycle noise becomes noticeable.
Thermal Noise -

Noise associated with the rapid and random movement of electrons within a conductor.

Thermal Agitation

Brownian Motion

1927 Nyquist Johnson

Johnson Noise

White Noise

Fluctuations occur at all freqs.
THERMAL NOISE -

Noise associated with the rapid and random movement of electrons within a conductor due to thermal agitation.

J.B. Johnson 1927 Bell Labs - Specific Brownian Motion - General

Johnson Noise

Also white noise - random movement produced fluctuations observable at all fields.