Module II

Lecture 6

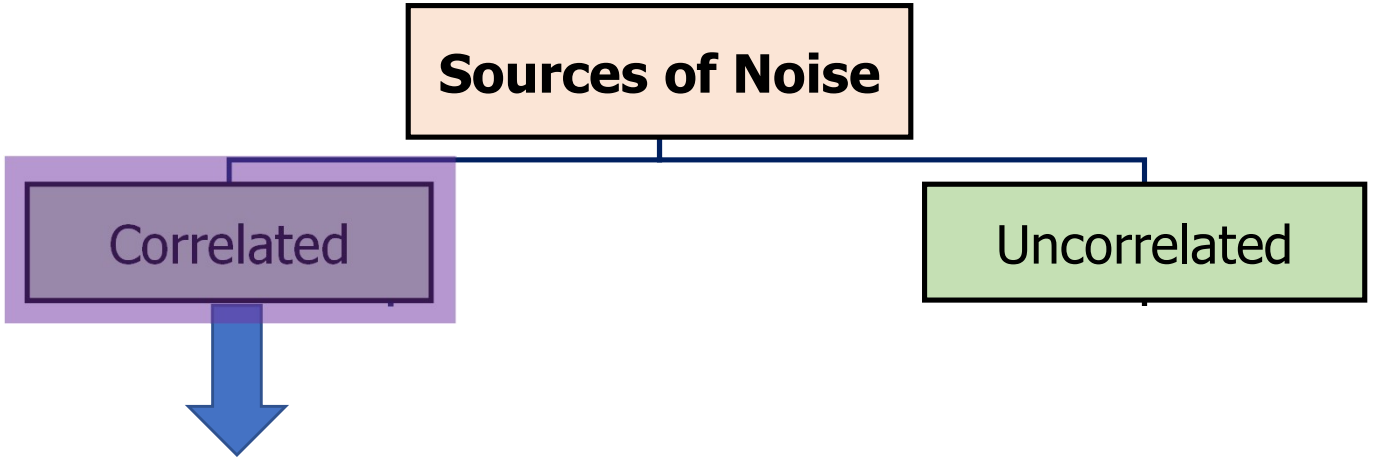
- Noise in Communication Systems
- Types of Noise

Noise

- Important parameter in communication design
- Affects receiver more as signal weak there
- Unwanted, undesired signal that interferes with the desired signal
- Gets superimposed on signal and impossible to separate signal from noise
- Random in nature
- Examples: hiss, crackle, snow

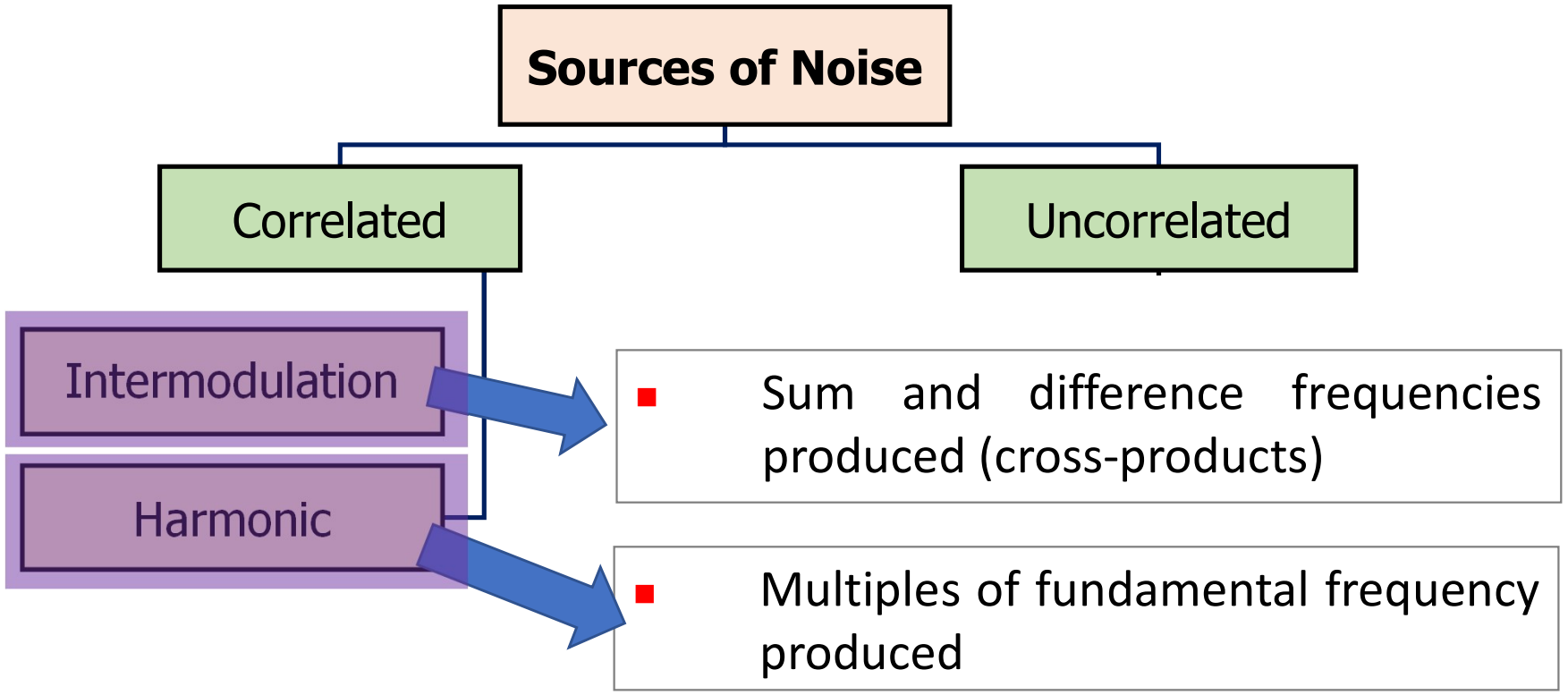
Objective: To produce highest possible SNR

Classification of Noise



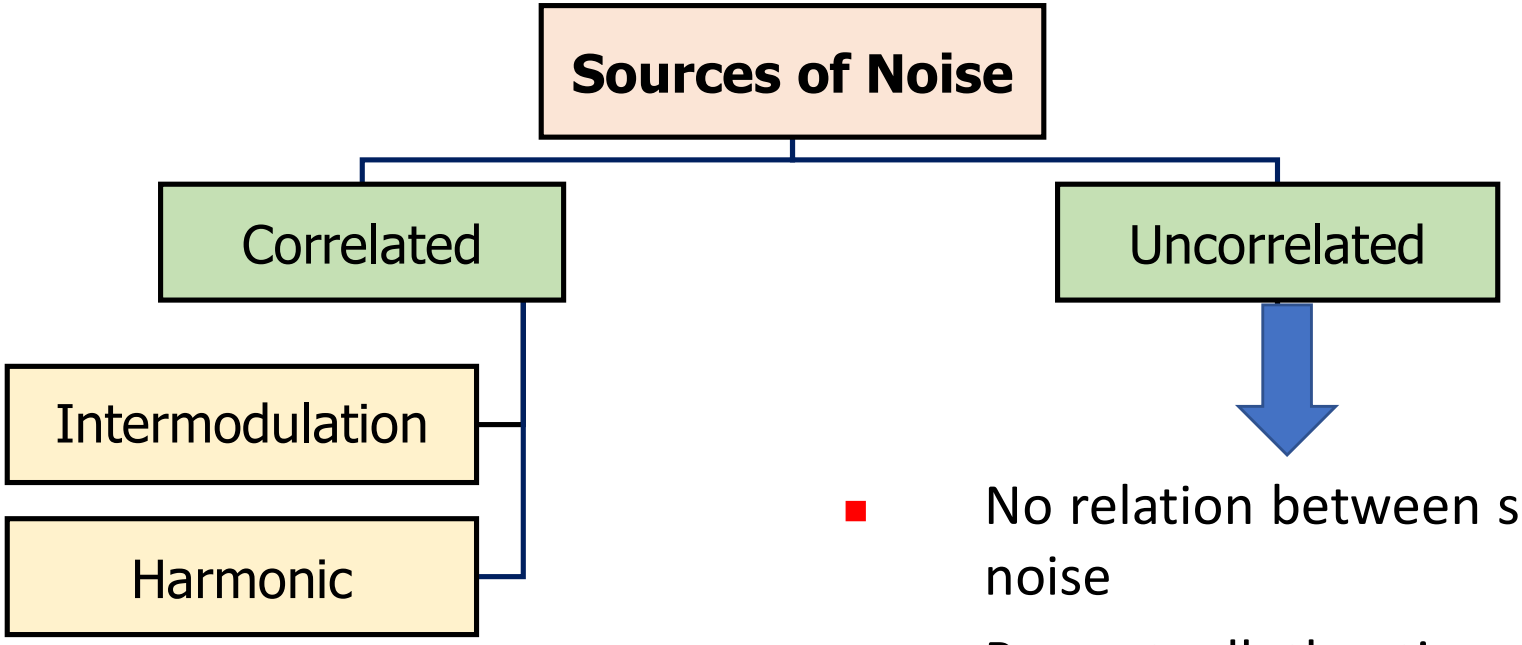
- Exists a relation between signal and noise
- Exists only when signal is present

Classification of Noise



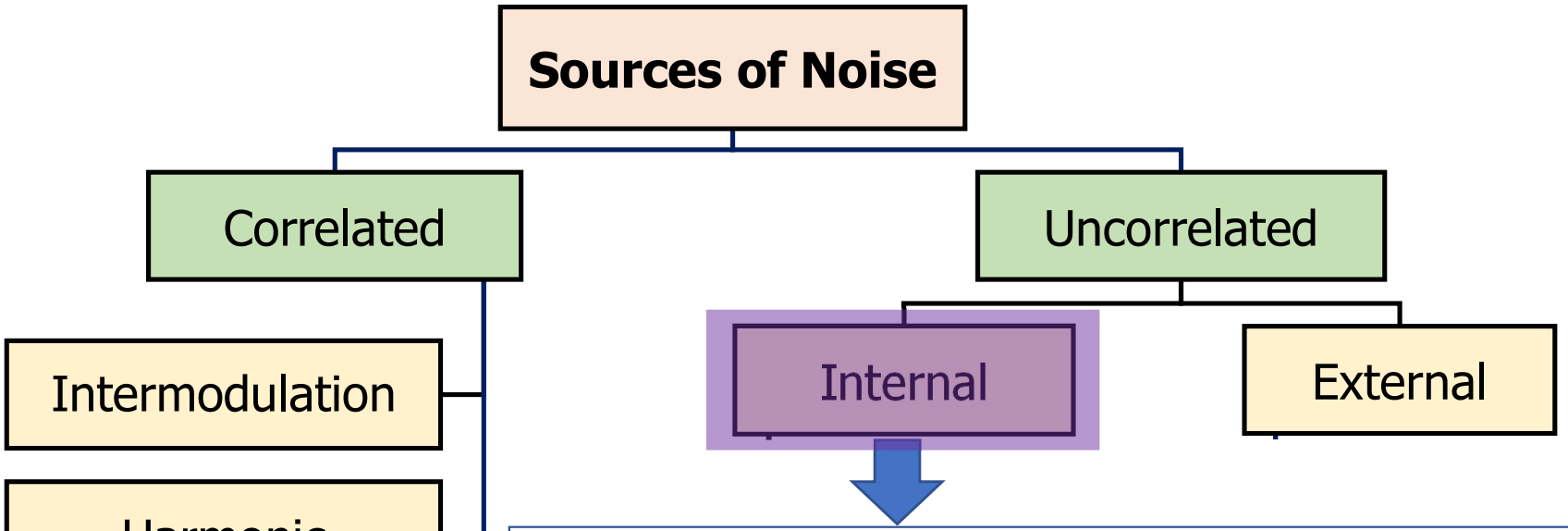
- Produced when signal passes through nonlinear devices like diodes, FET
- Hence, both together also called as nonlinear distortion

Classification of Noise



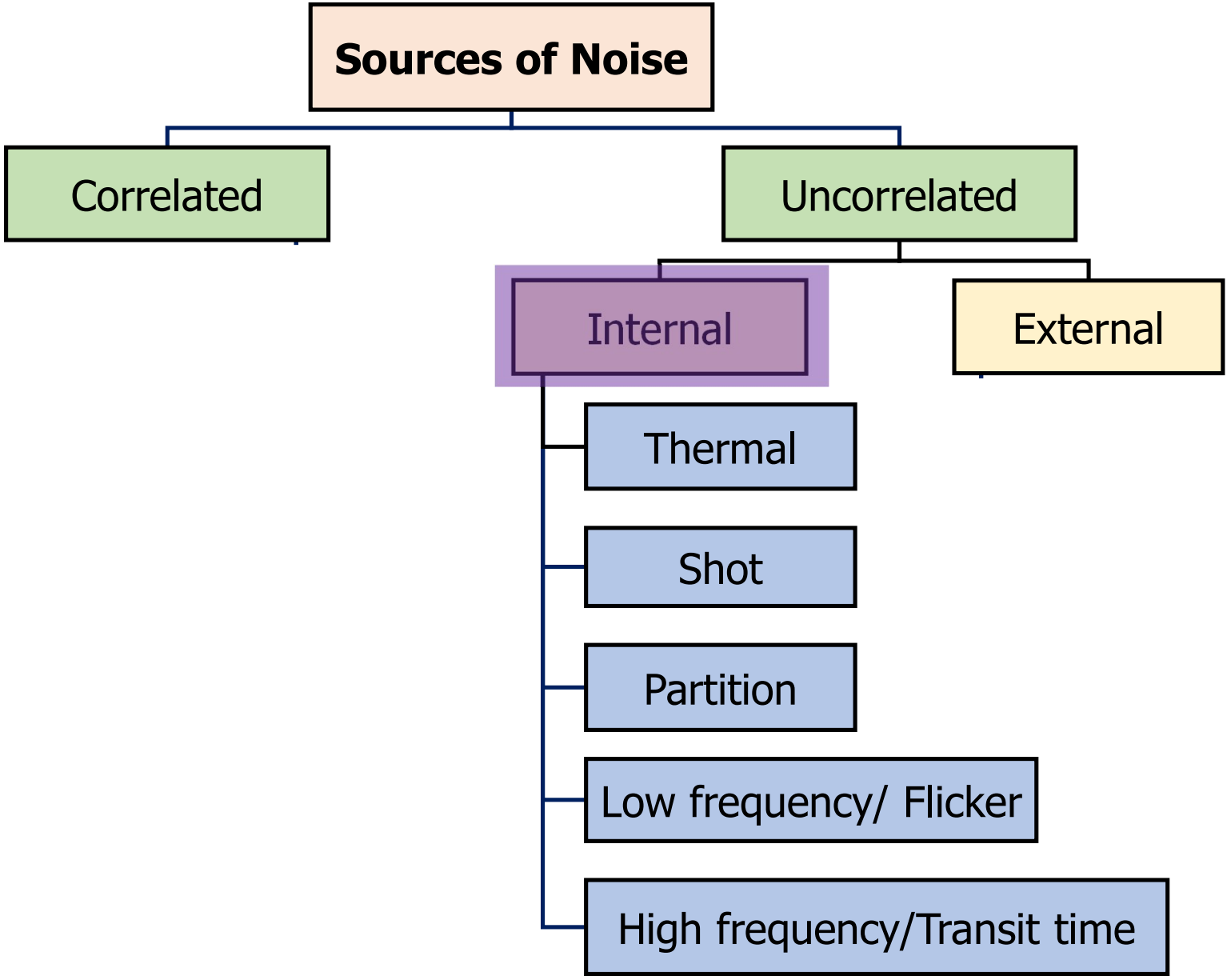
- No relation between signal and noise
- Present all the time whether there is signal or no signal

Classification of Noise



- Generated within the device or circuit
- Integral part of physical nature of material used for manufacturing components
- Produced by resistors, diodes, transistors
- Low level noise
- Affects weak signals more
- Obeys certain laws and hence we can design equipments where it can be minimized

Classification of Noise



Thermal noise/ White noise/ Johnson noise

- Due to **rapid and random movement of free electrons** within a conductor due to thermal agitation
- Thermal noise power, $P \propto$ BW (B) and Temp (T)
- $N = KTB$
- Power spectral density, $S_n = N/B = KT$ W/Hz
- Since equally distributed throughout the frequency spectrum, also called White noise
- To minimize the effect…
  - Noise depends on temperature… So keep temperature low
  - Noise contains a large no. of random frequency components and noise level dependent on BW of circuit…So, use BPF
  - Noise depends on amount of current flowing in a component… So, keep I low

- Consider an equivalent circuit for a thermal noise source where internal resistance R_1 is in series with rms noise voltage, V_N
- For maximum transfer of noise power
  - $R_L = R_1$
  - $V_{R_L} = \frac{V_N}{2}$
- Hence, noise power developed across $R_L = KTB$
  - $N = KTB = \frac{\left[\frac{V_N}{2}\right]^2}{R_L} = \frac{V_N^2}{4R_L}$
  - $V_N^2 = 4KTBR_L$

where, Boltzmann constant, K = $1.38064852 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}

Shot Noise

- We assume that current in electronic devices under dc condition is constant
- However, its only time average flow of electrons which is constant
- Caused by random arrival of carriers at output element
- Sounds like a shower of lead shots on a metal sheet
- Inversely proportional to g_m of device
- Mean square shot noise current is given by –

$$I_n^2 = 2I_{dc}q_eB \text{ Amp}^2$$

where, I_{dc} is direct current in amperes

q_e is the magnitude of the electron charge (1.6×10^{-19} C)

B is the equivalent noise bandwidth in Hz

Partition Noise

- Occurs when current has to divide between two or more paths and results due to random fluctuations in division of current
- eg. BJT : random motion of carriers crossing junction and random recomb. in base (random division of current between C and B)
- Higher in BJT than diode
- Noise generated depends on Q-pt and source R

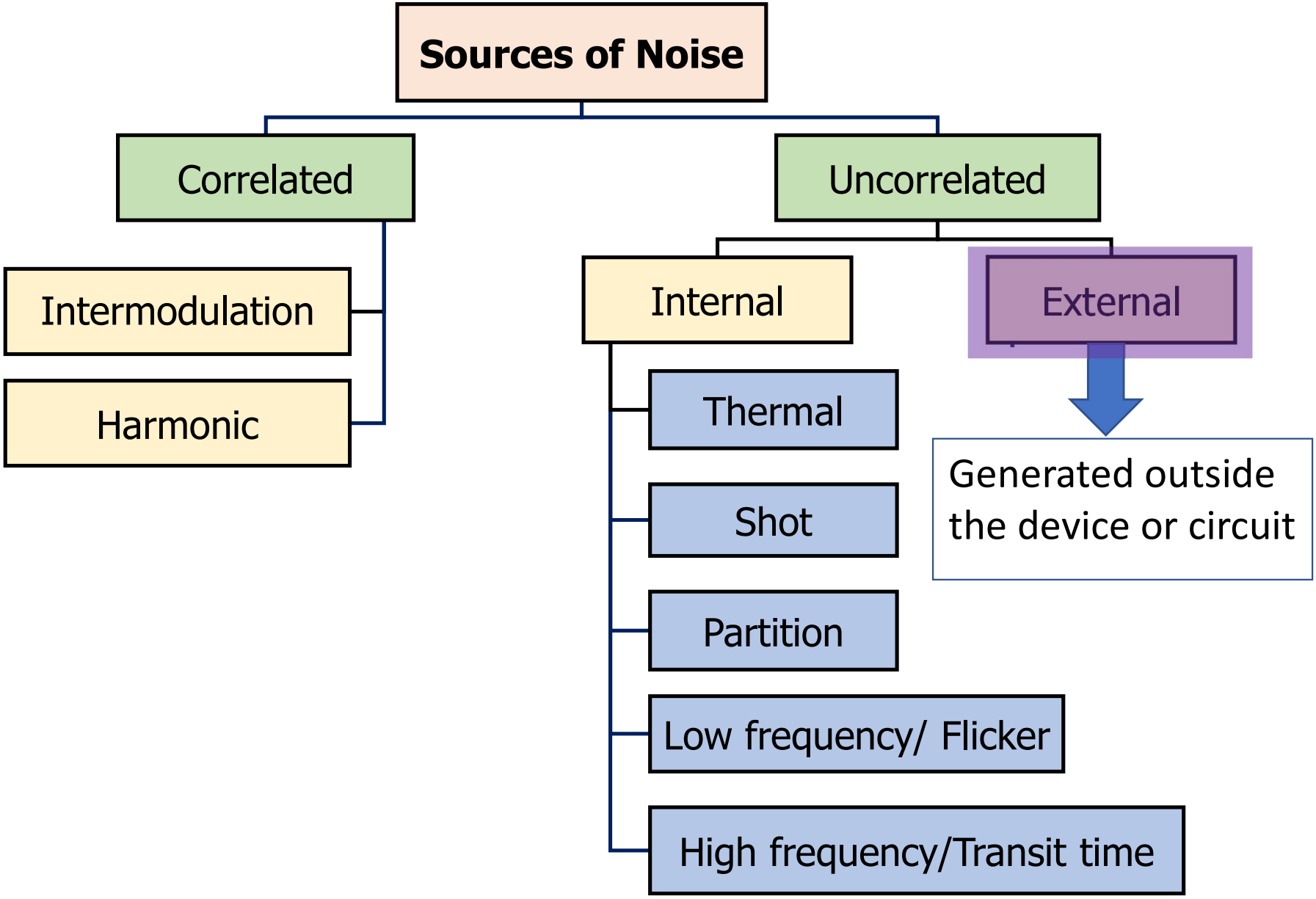
Low frequency/ Flicker Noise

- Appears for frequency < few kHz
- Inversely proportional to frequency
- It is due to fluctuations in carrier density which in turn affects the conductivity… Hence…. fluctuating voltage drop produced
- Proportional to square of direct current flowing through the device

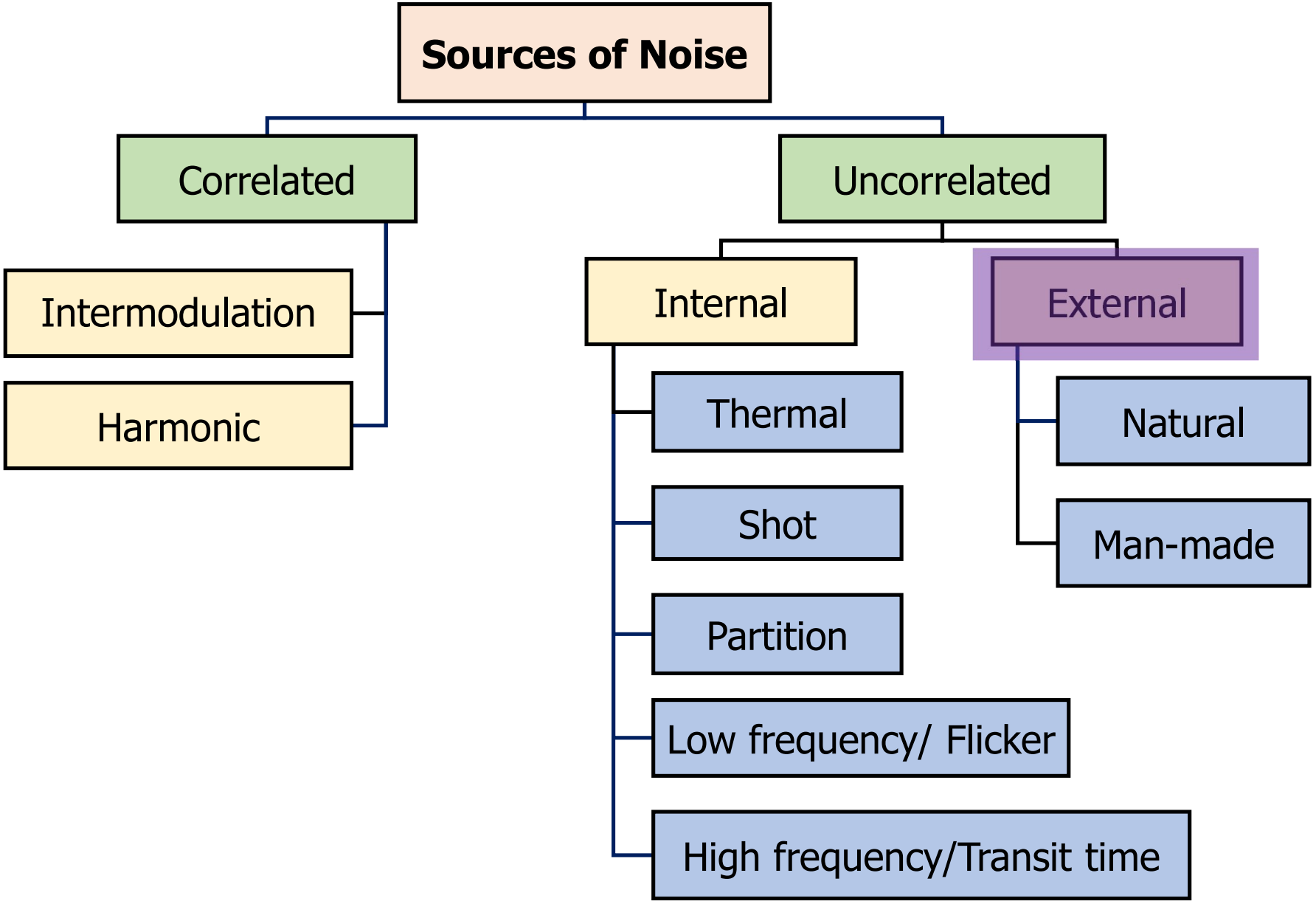
High frequency/ Transit time

- Transit time defined as time taken by carriers to cross junction
- When signal frequency high, periodic time small and maybe comparable to transit time
- Hence, some carriers may diffuse back to the source
- This results in a kind of random noise
- Determined by carrier mobility, bias voltage and transistor construction
- This noise is proportional to frequency of operation

Classification of Noise



Classification of Noise



Types of External Noise

- **Natural**
  - **Atmospheric** – produced within Earth's atmosphere
    - Lightning (electrical disturbance)
    - Electric discharge between clouds and between clouds and earth
  - **Extra-terrestrial** (Source - space) - Two types
    - Solar (Source - Sun)
    - Wide range of signals in a broad noise spectrum
    - Vary with time
  - **Cosmic** (Source - Stars)
    - Impact less because of distance
    - Greatest impact in 15-150MHz

- **Man-made Noise**
  - Industrial – generated due to make and break process in a current carrying circuit
  - Automotive ignition systems
  - Electrical motors
  - Fluorescent lights
  - Welding
  - Switching gears
  - Gas filled tubes
  - Can be minimized by controlling it