



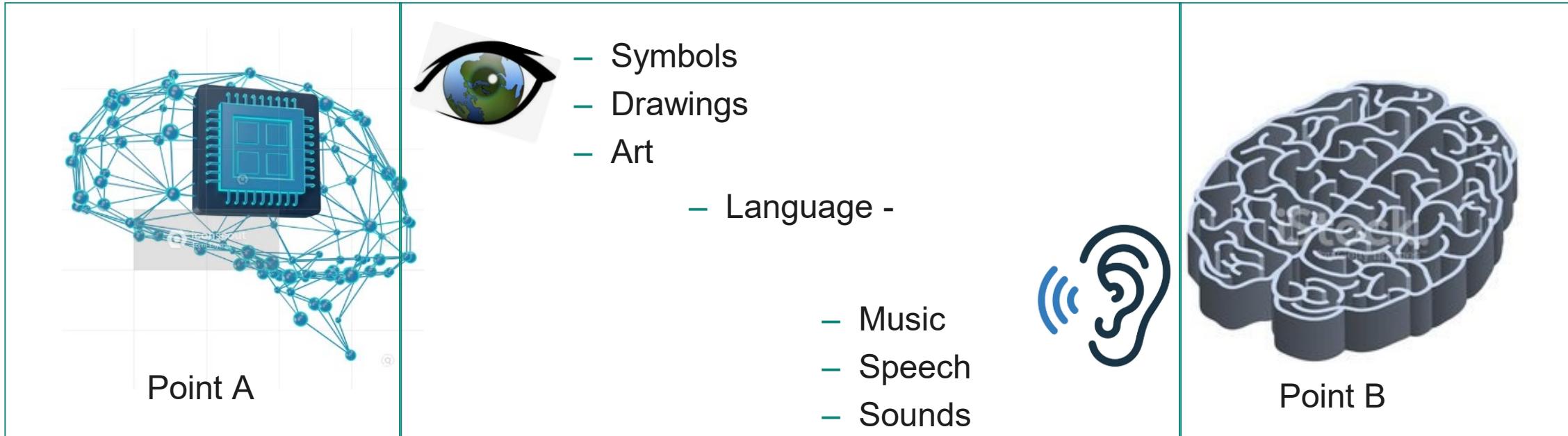
# **Power Amplifier Module (PAM)**

## **Welkom bij Infineon Technologies B.V**

Nijmegen design team  
13-11-2023



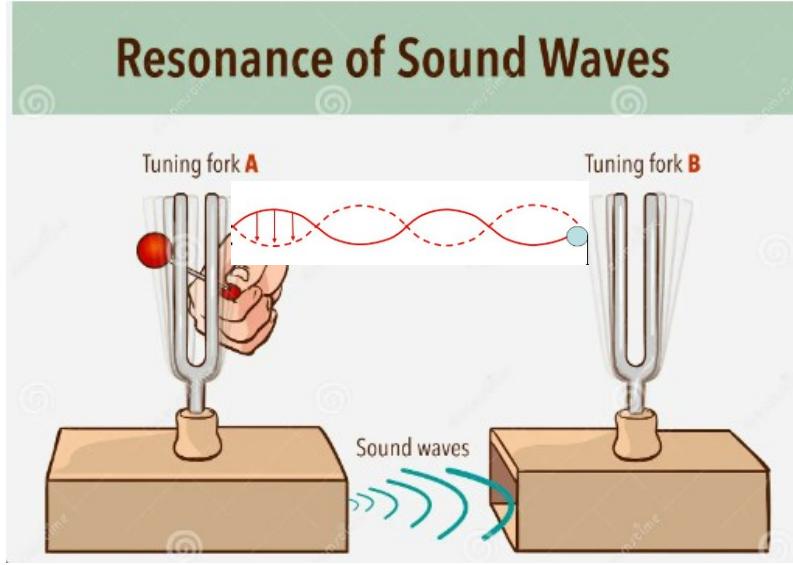
# 1. Communication & evolution



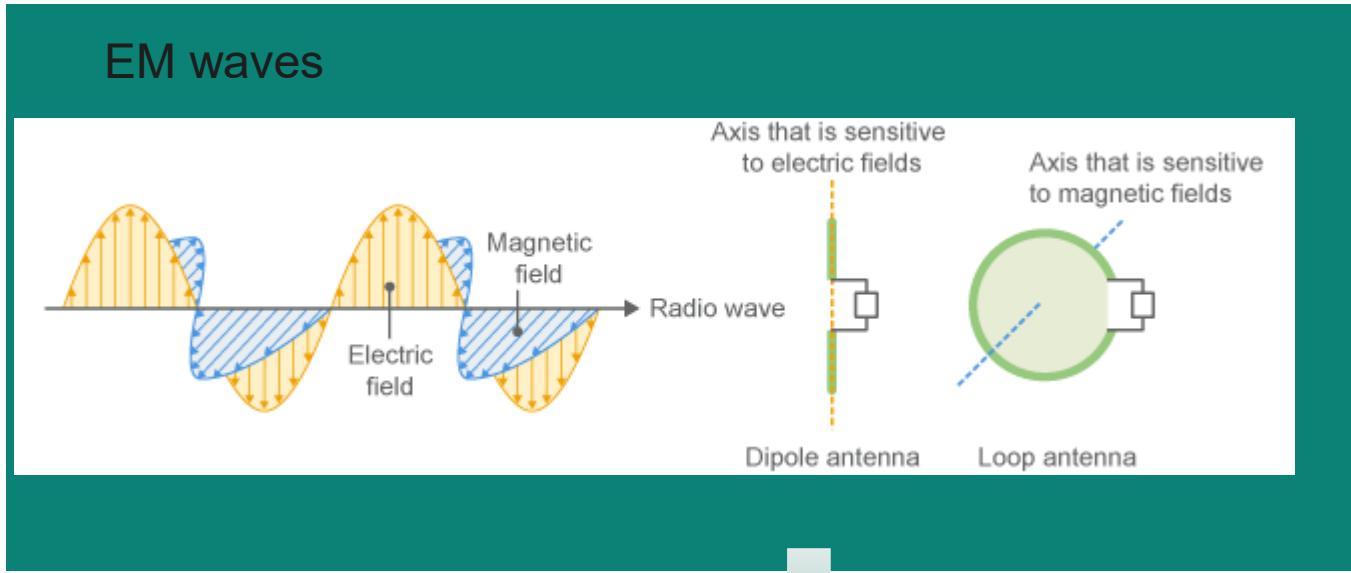
- Senses gather information and pass it to brain for processing.
- This processed information becomes knowledge.
- Interactions & communication is necessary to share knowledge and expand/calibrate world view.
- The quality of interaction & effectiveness of communication is shaping humanity and civilizations on their evolution path.

## 2. Electro magnetic (EM) waves & Antennas

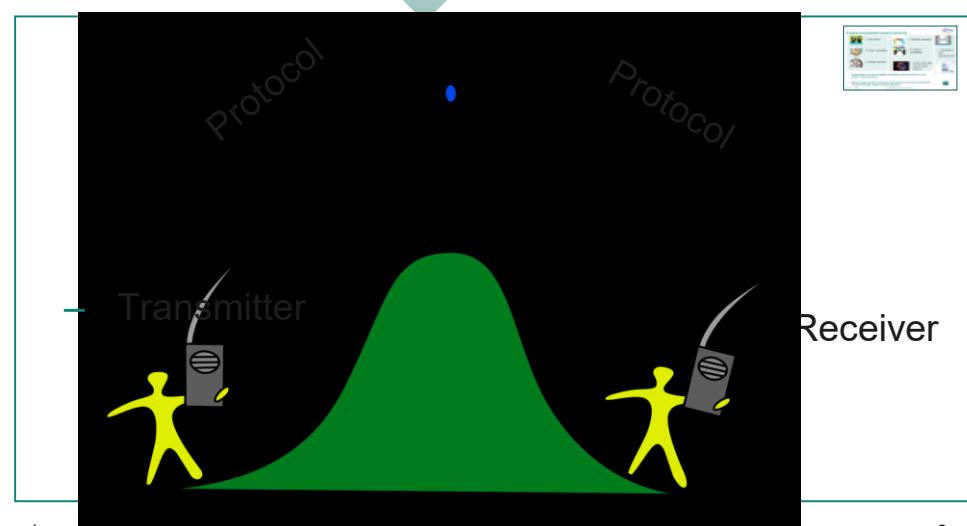
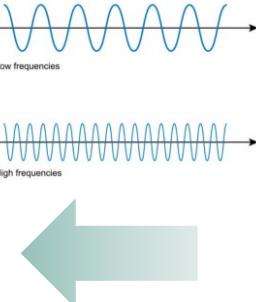
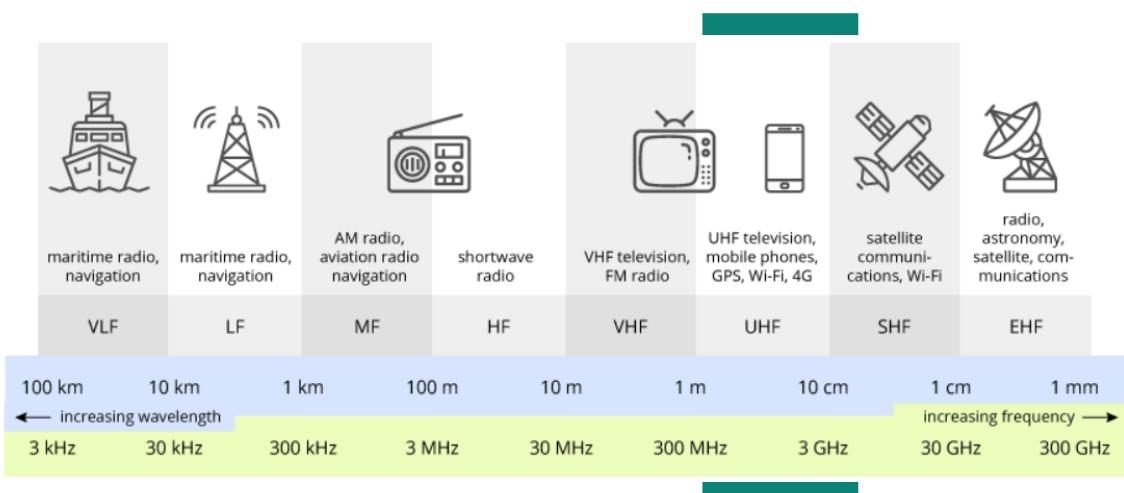
Mechanical ↔ sound



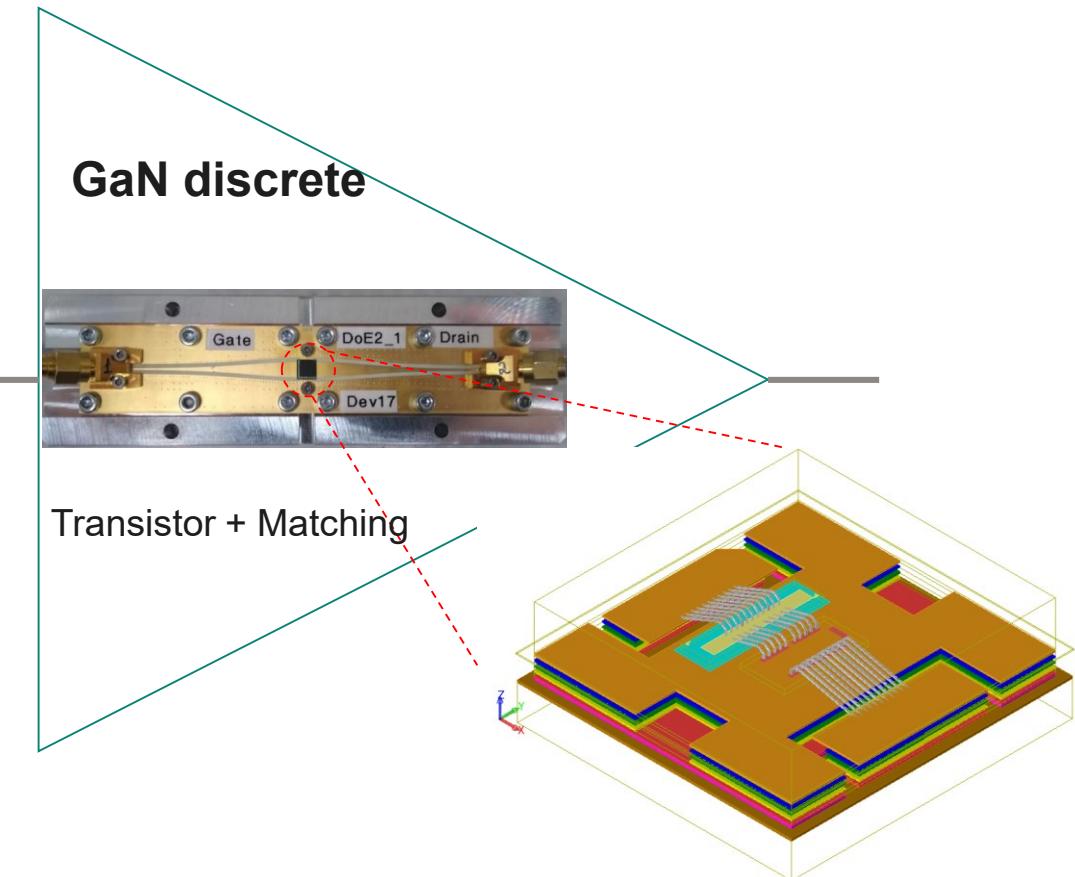
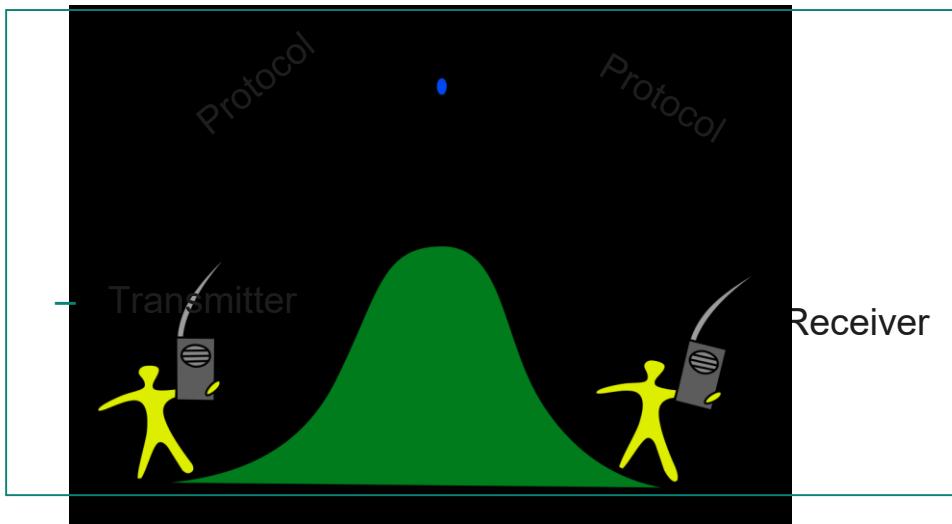
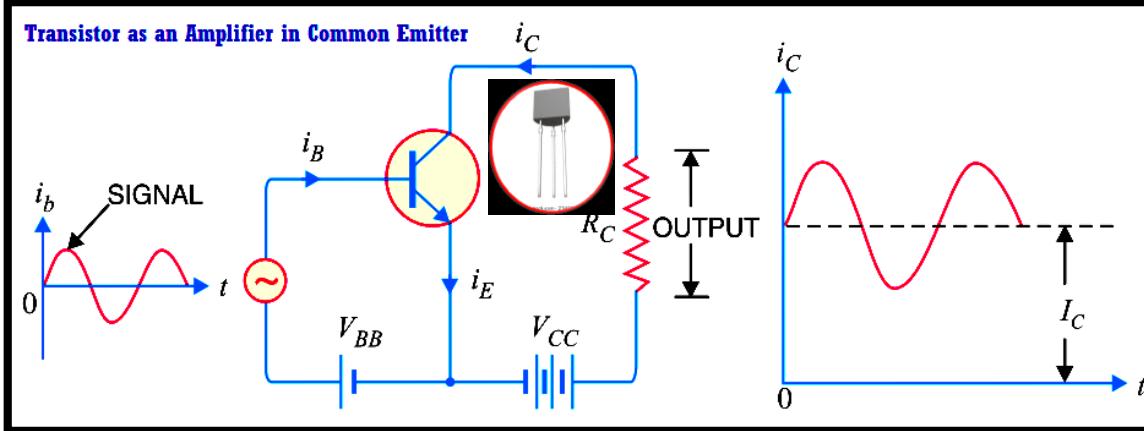
current ↔ EM waves



– Frequency & power

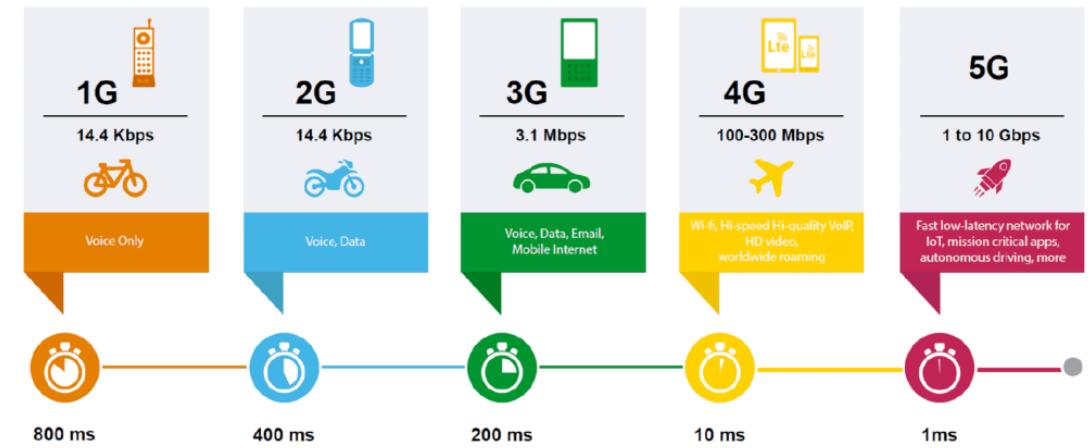
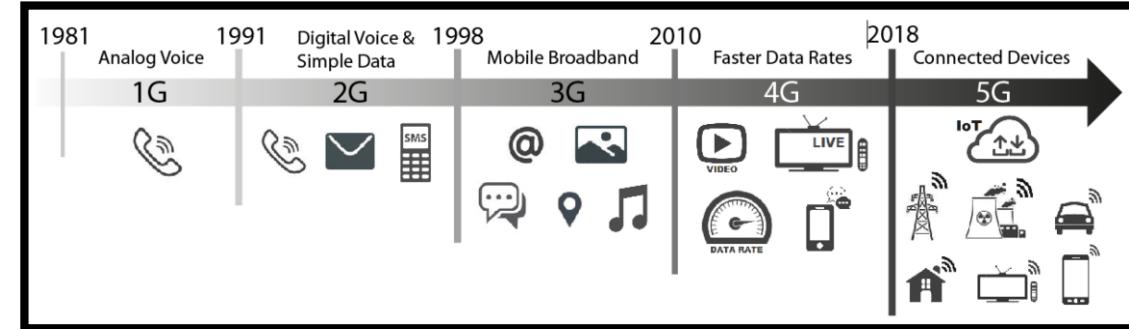
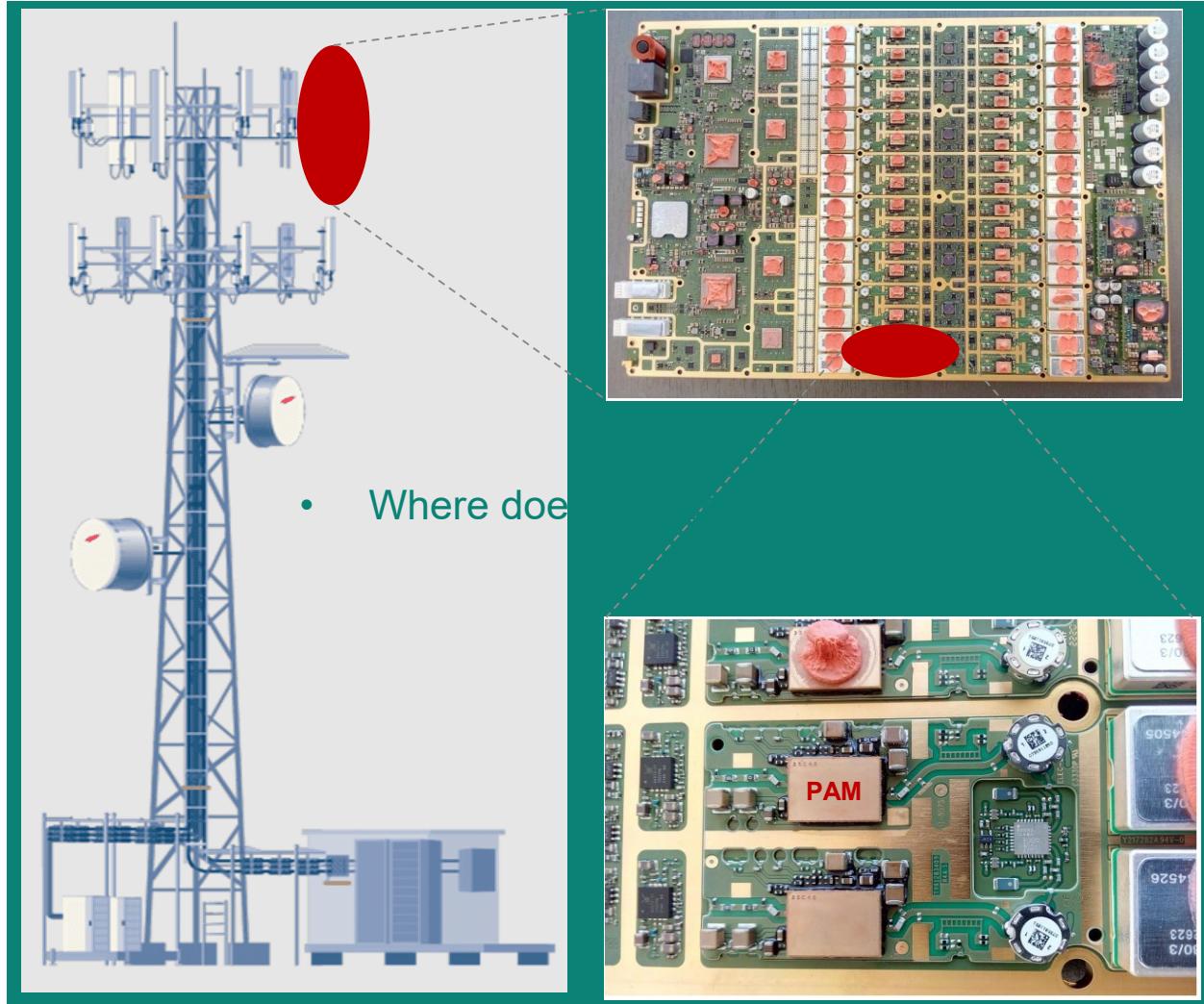


### 3. Transistor & amplifier (Power)

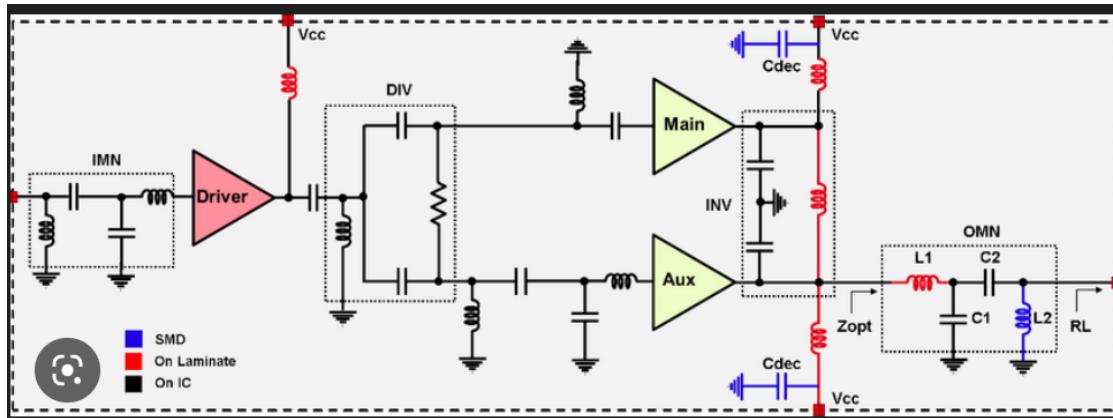


- Transmit high power signals from transmitter antenna
- Amplify weak signals from receiver antenna

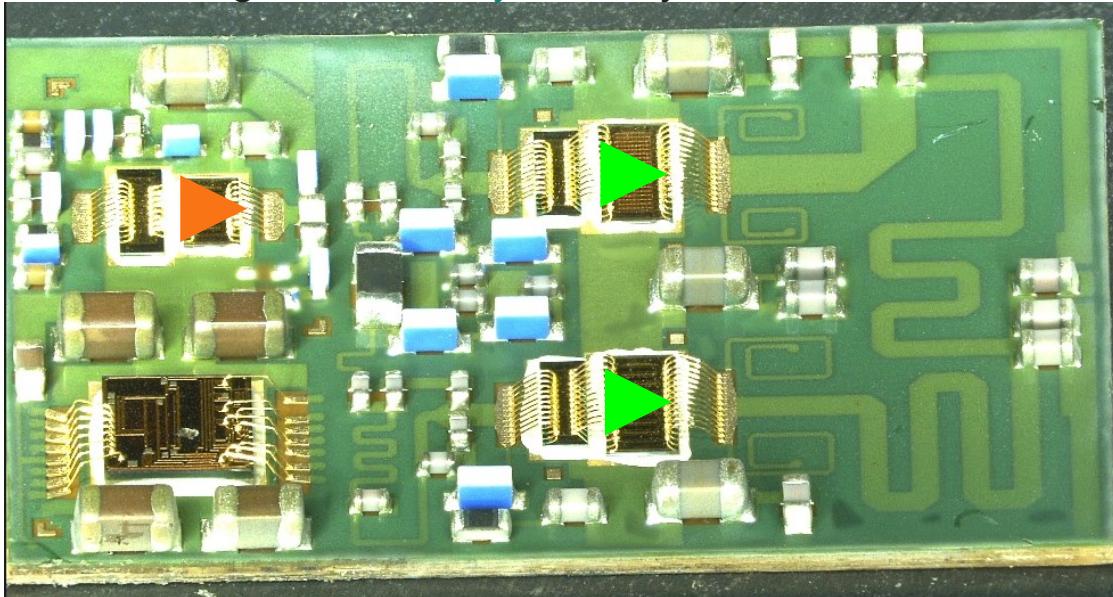
## 4. Evolution of communication networks (Frequency)



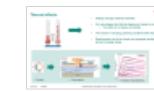
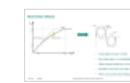
## 5. Power amplifier module (PAM) Design & challenges



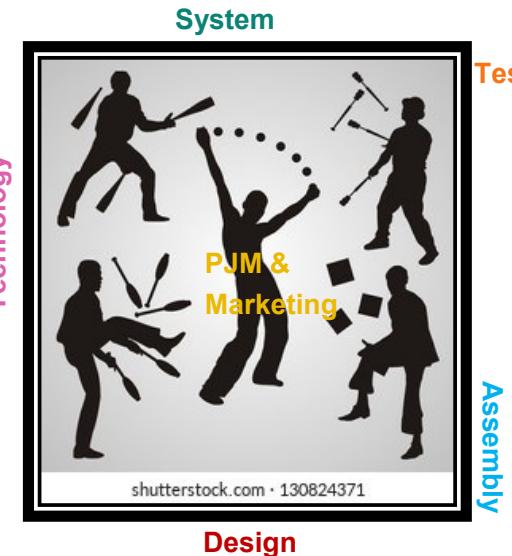
- Multi-stage amplifier
- Power, gain, efficiency, linearity



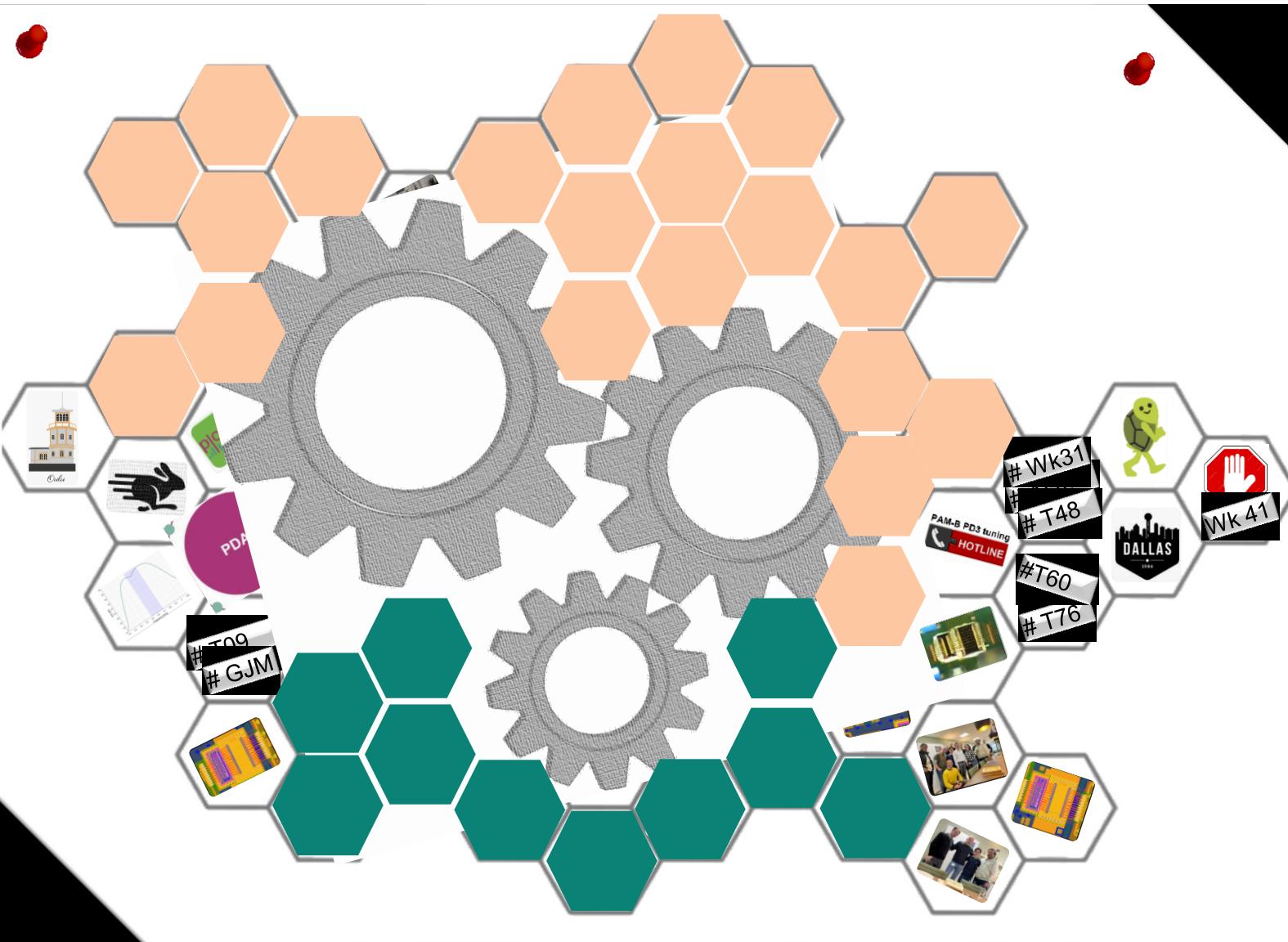
- Complexity
- Size & accuracy
- Assembly & process spread
- Model (non-linear)
- Thermal effects
- Time to market vs cost



Technology



## 6. People, process, collaboration & contribution

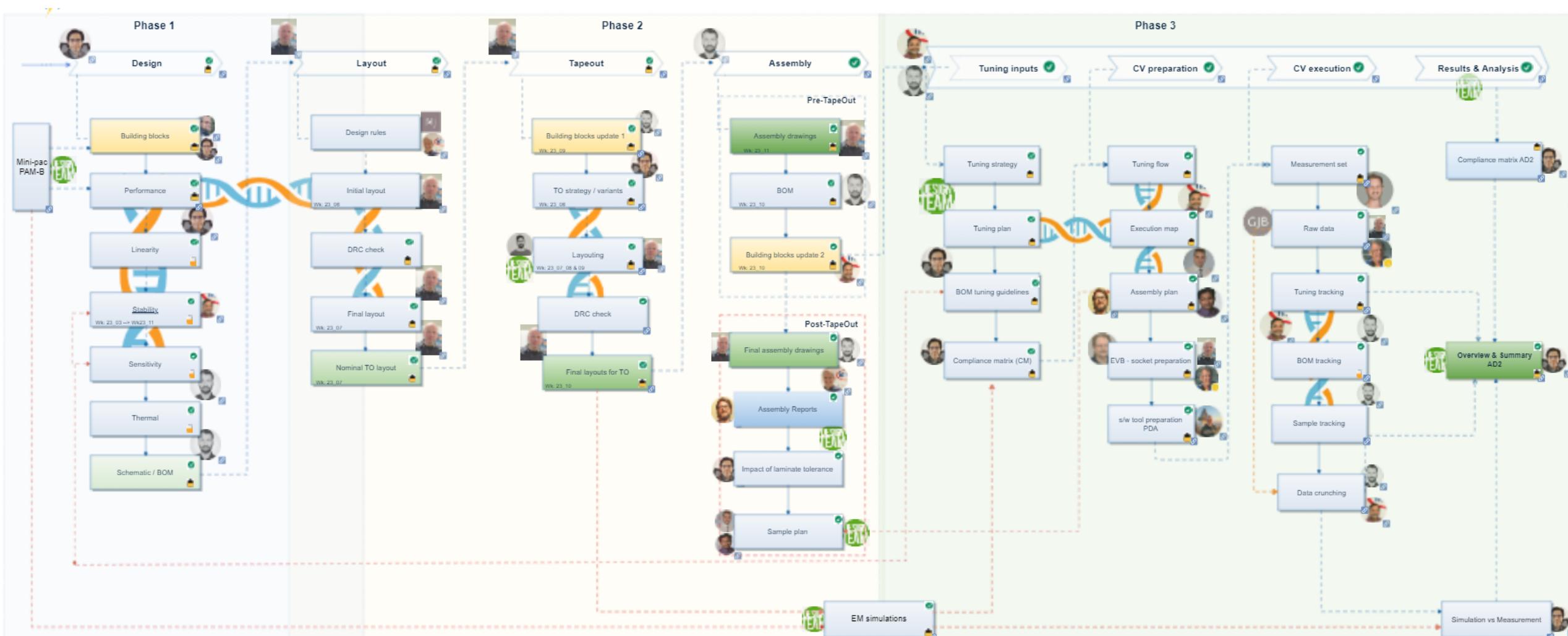


- State of the art GaN technology
- Strong technical community
  - Robust review & feedback
  - Great support & knowledge
  - Customer & application support
- State of the art assembly & test facilities
- Collaboration with external partners
- Project & design management
  - Keep track & link milestones to road-map, TTM.
  - Best use of resources.
  - Benefit from Infineon's robust internal processes & tools.
- External partners funding for part of the project will get to benefit from Infineon's full resources.

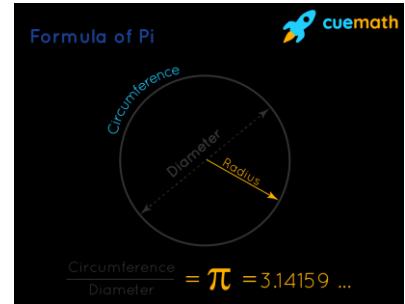
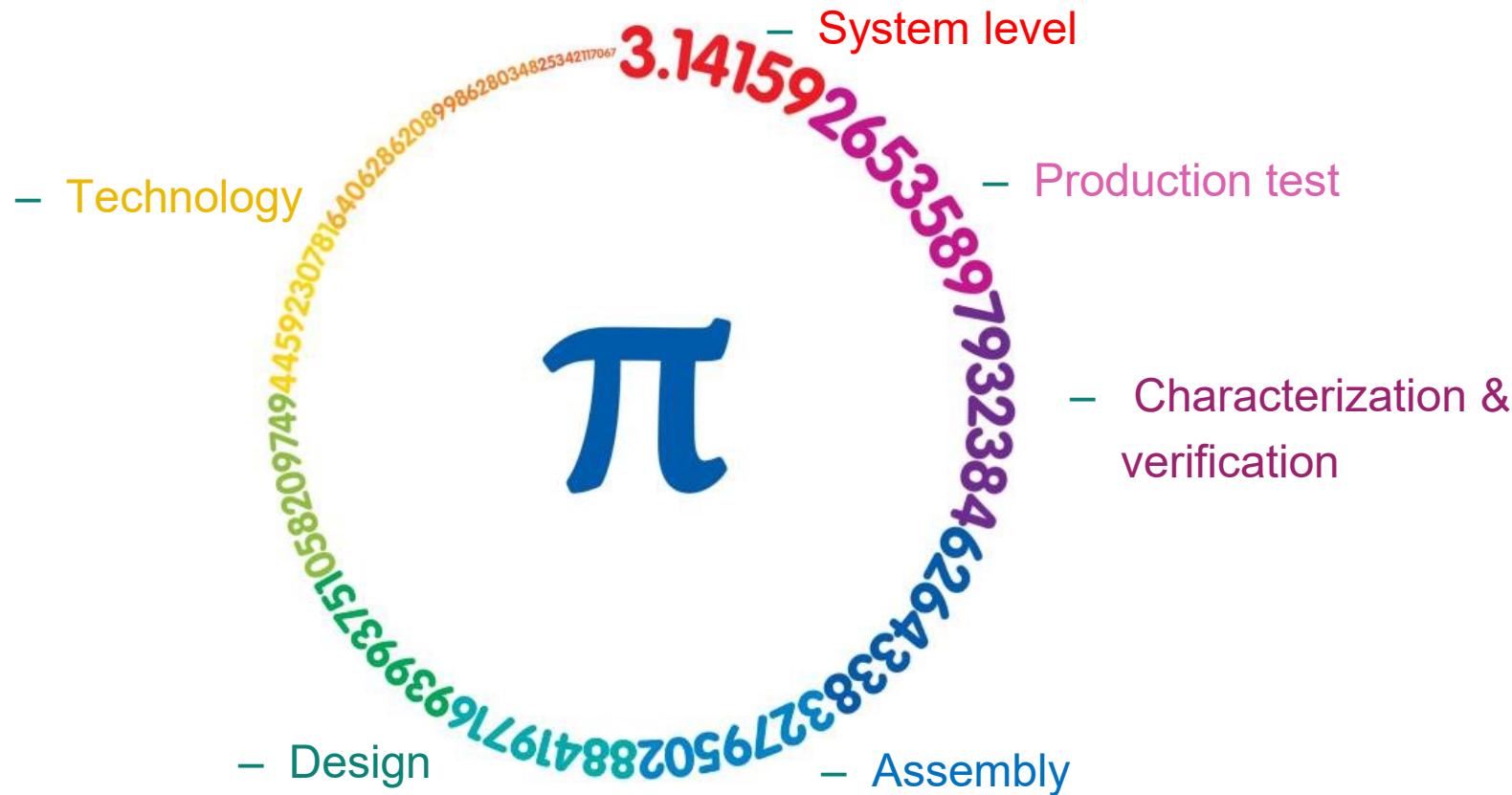


**Thank you!**

# Complexity (PAM design flow)



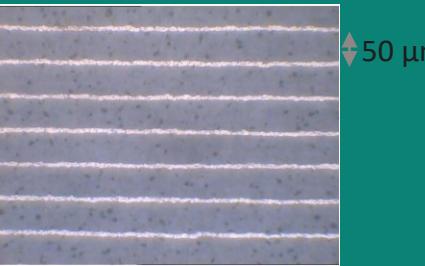
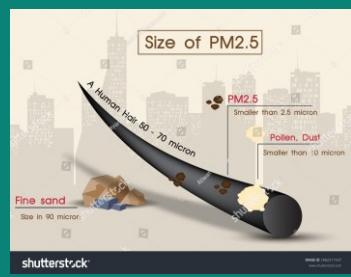
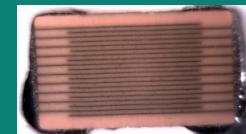
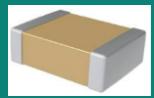
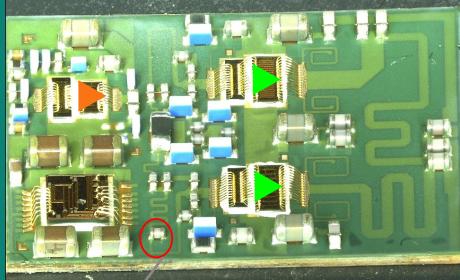
# Size and accuracy



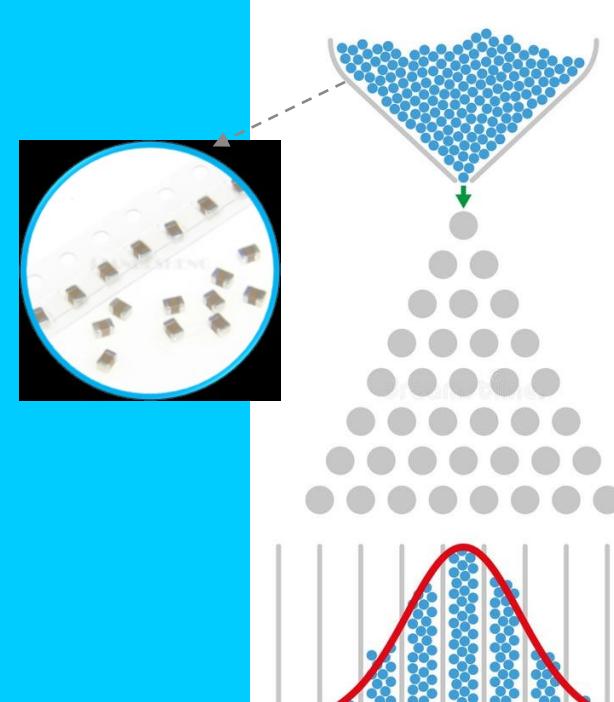
- The lower you go in size of dealing things, the stringent will be the accuracy requirements
- This picture is an illustration & analogy

# Assembly & process spread

## Scale and accuracy



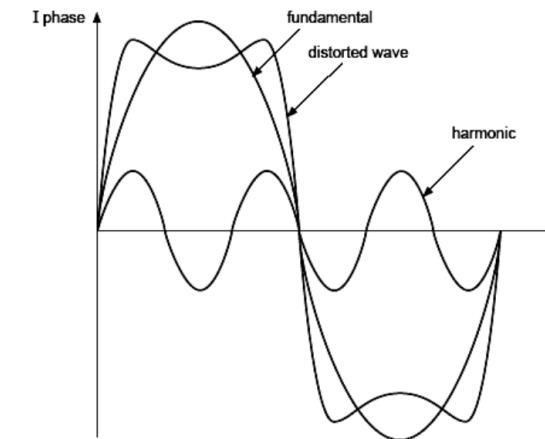
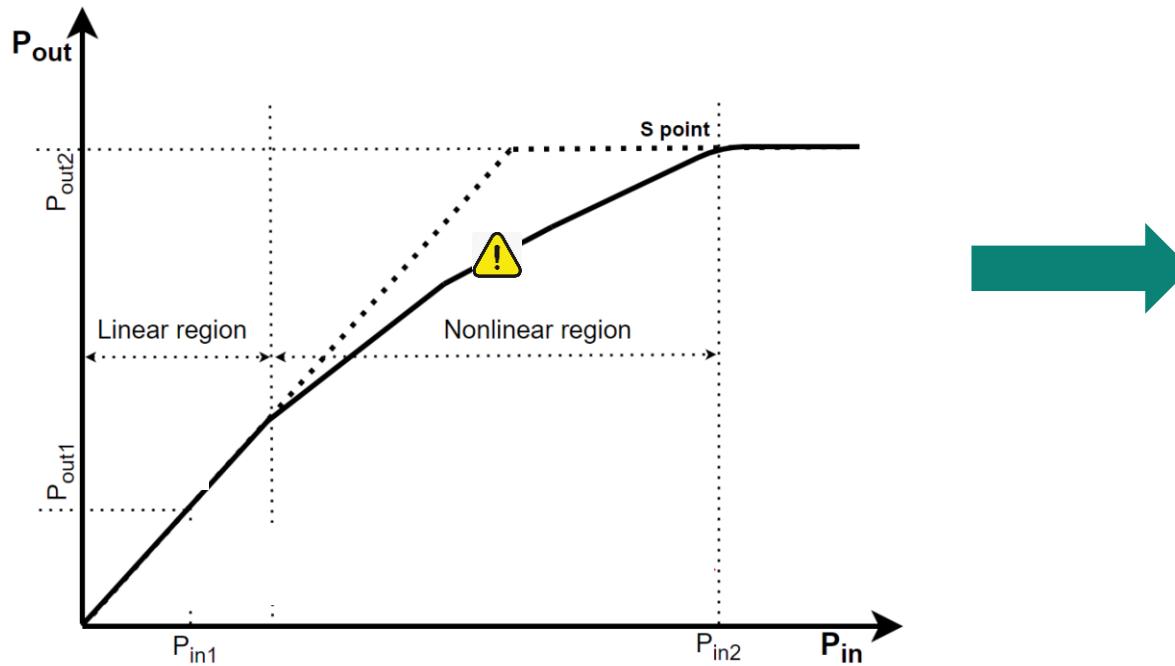
## Process tolerance



- Tolerances in
  - Technology
  - Assembly placement
  - Components & materials
  - Packages

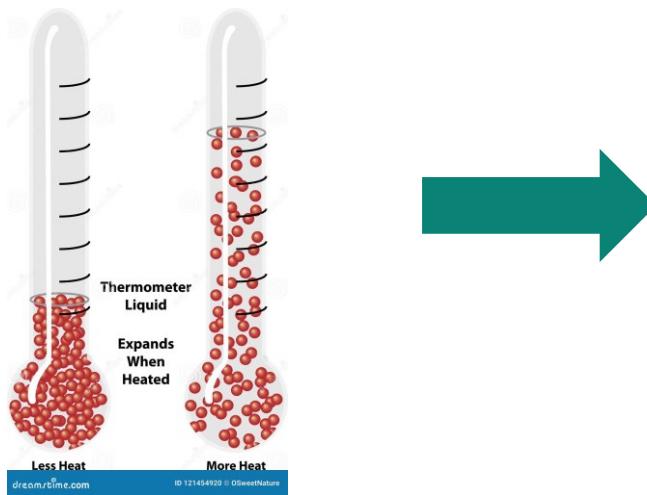
- Design has to account for assembly & process spread to avoid yield loss.

# Non-linear effects

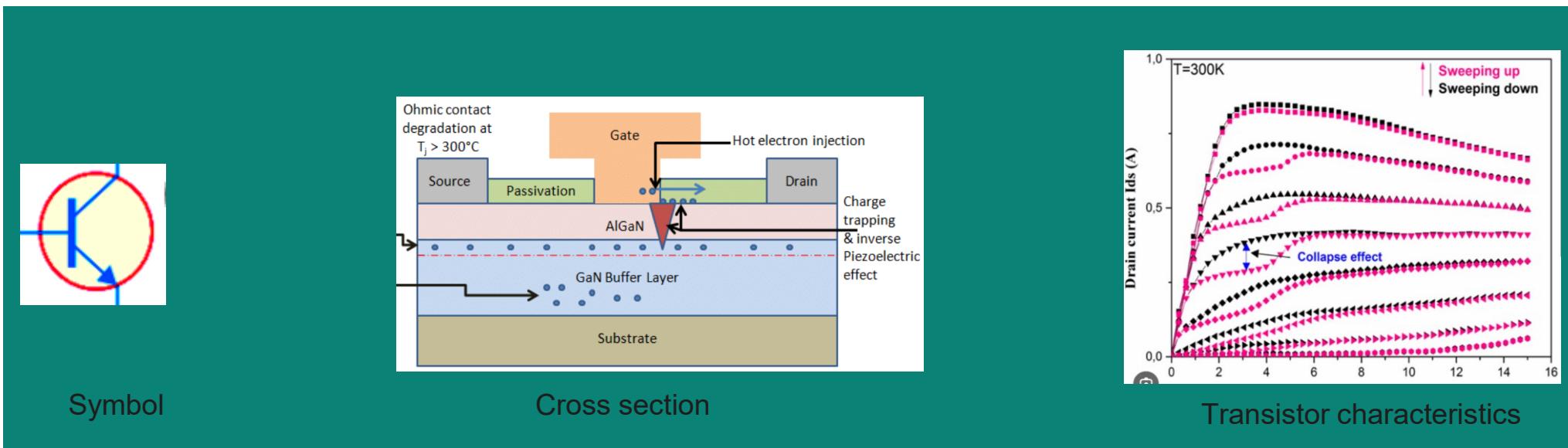


- Linear region is easy to model
- Non-linear region is un-predictable & difficult to model
- Either causes interference or loss of partial information.
- Simulation tools cannot be fully exploited for design
- Have to be cautious about design choices

# Thermal effects



- Heating changes material properties.
- For technologies like GaN de-trapping of charge is more likely.
  - This effect is not always immediate
- This results in changing operating conditions after design.
- Dies/transistor has to be chosen and prepared carefully during the design phase





# A typical communication scenario (protocol)



1. First contact



2. Check compatibility



3. Gauge resources



4. Establish connection



5. Engage in conversation

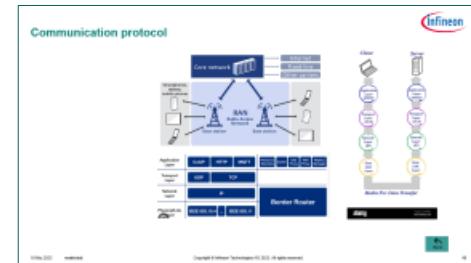


6. Alter, enrich, build new information pathways



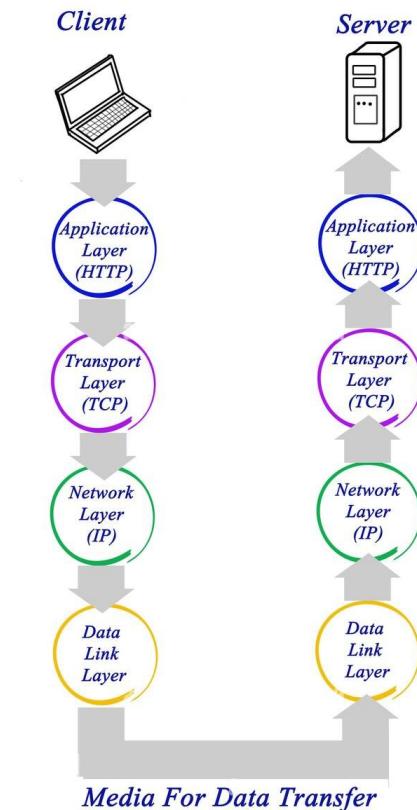
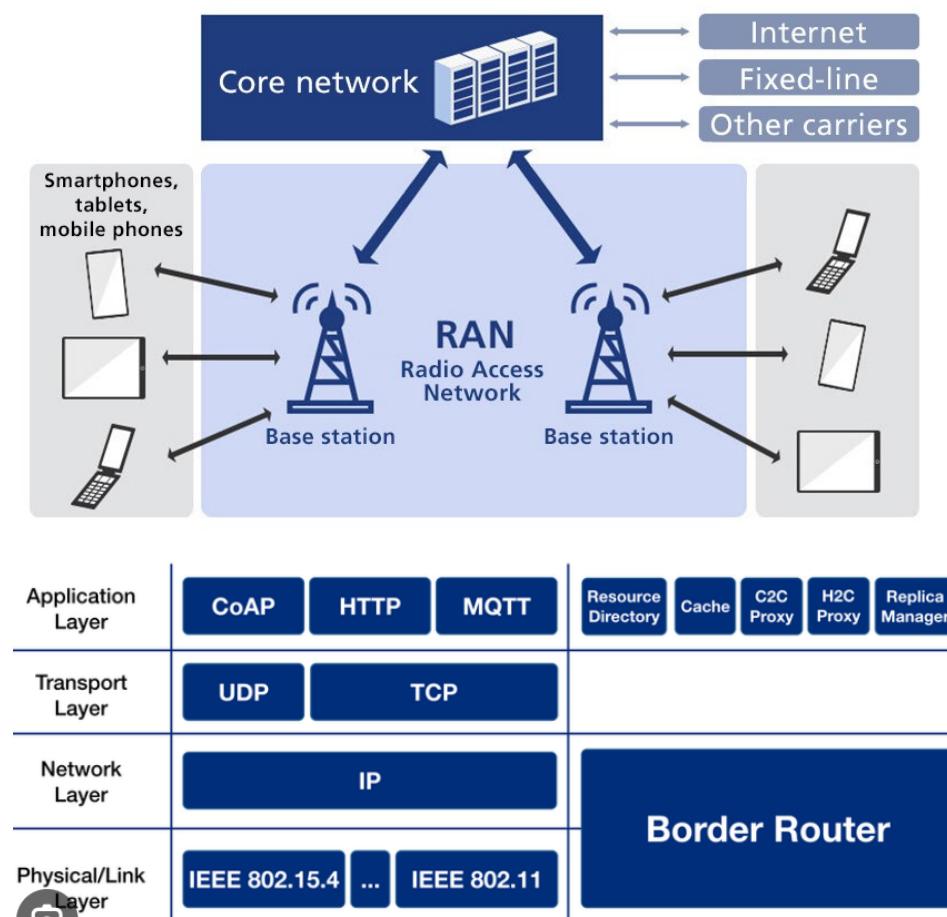
7. Disengage or keep connection active

- Communication is the art of engaging, transferring & storing interactions for the benefit of future generations
- Infineon is playing its part in making this communication infrastructure economically and environmentally viable for wireless applications.



Back

# Communication protocol



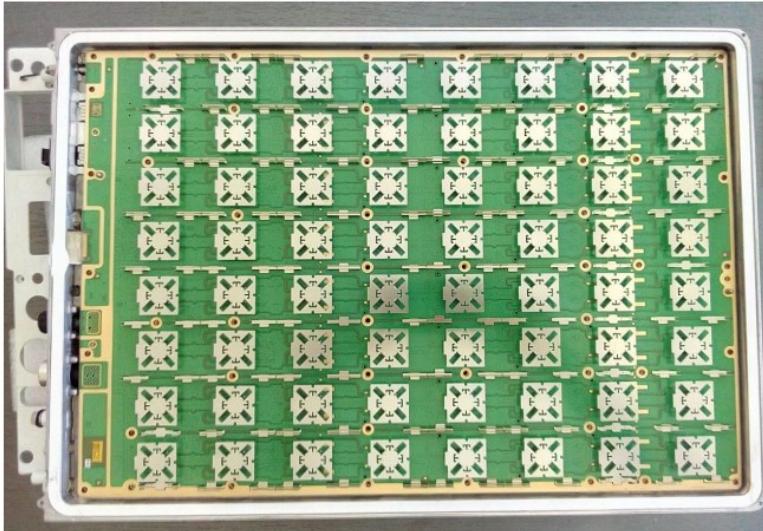
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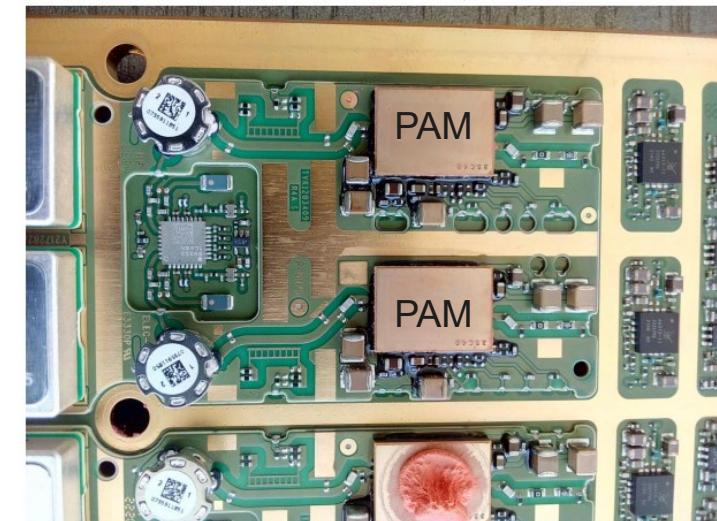
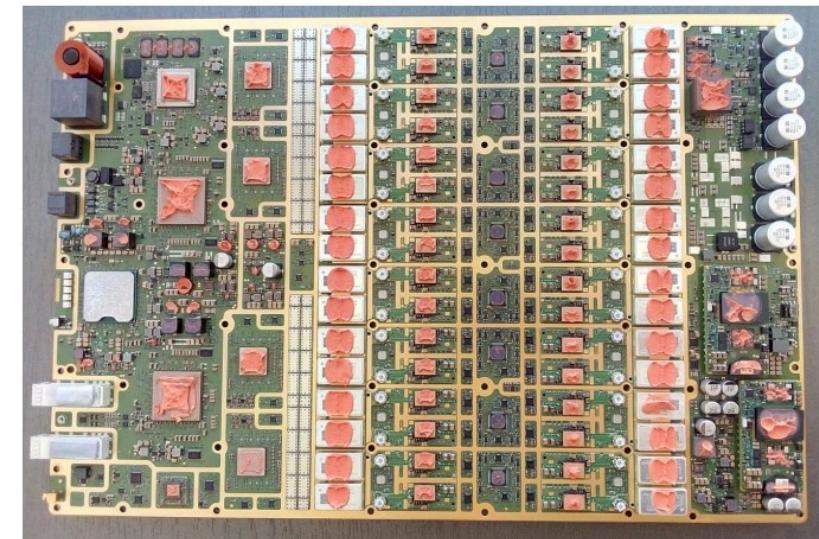
# Base station (inner view)



Antenna array



Amplifier array



Side view

