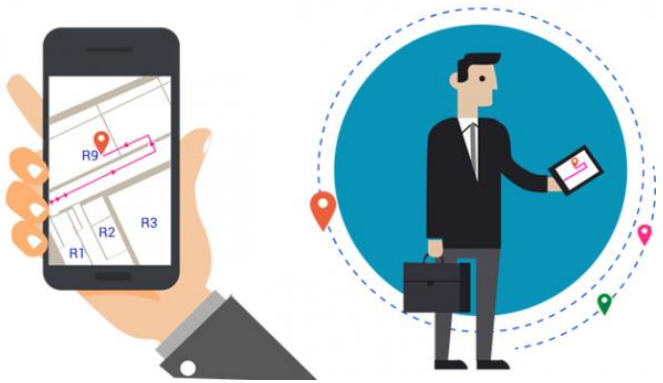
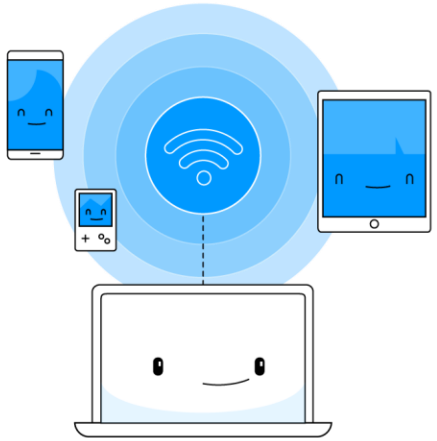
Dhruva: A Global Navigation Receiver

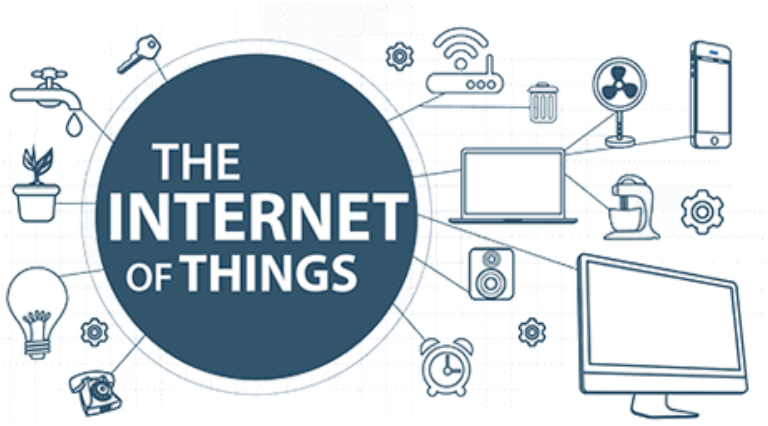
Vijay Kanchetla
aiCAS Lab
EE, IIT- Bombay
Supervisor: Prof. Rajesh Zele

SRG Session -1 Autumn 2020

Transceivers in everyday life







Many more....

Image Source: Internet

Outline

- RF signal transmission
- Fundamentals of Wireless Transceiver
- Positioning with Navigation systems
- Navigation signals
- Dhruva –A Mutli-Band Navigation Receiver (Made in IIT-B)

Radio Frequency (RF) Bands

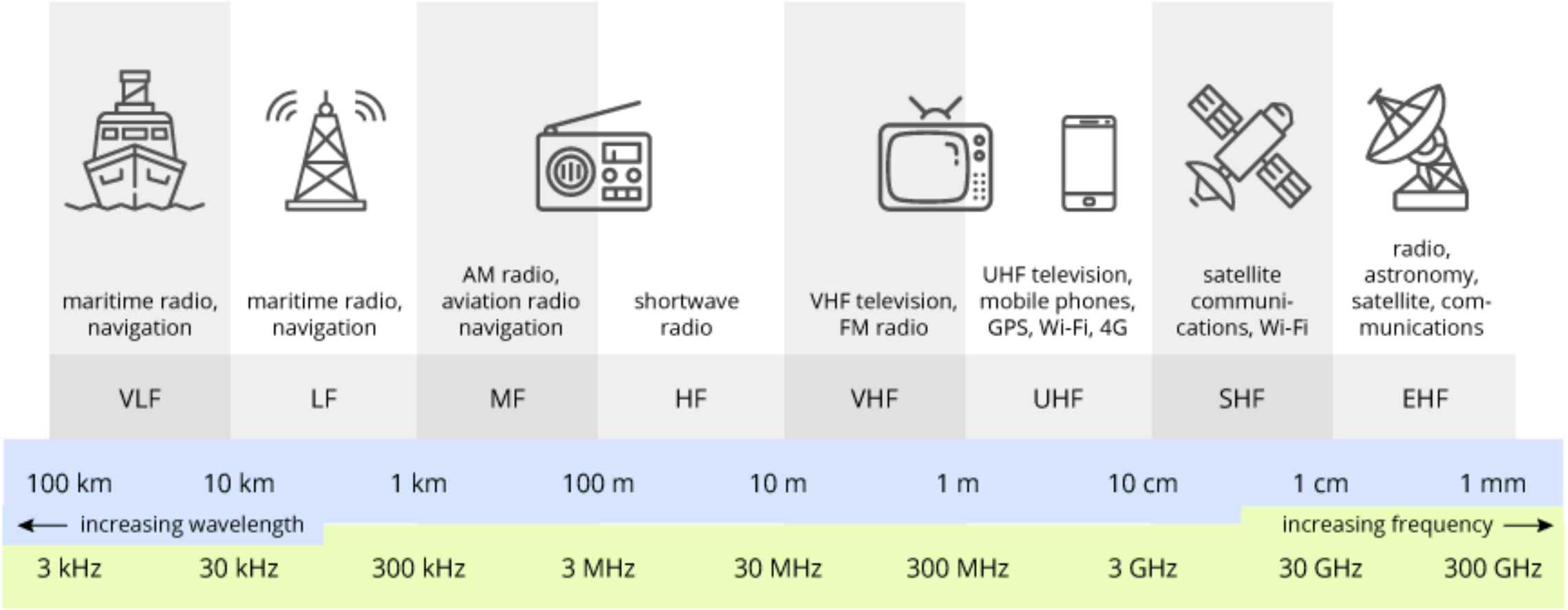


Image Source: terasense.com

RF transmission

- Power radiated is inversely proportional to (frequency)^2 and (distance)^2
- Longer wavelength (low frequency) signals
  - travel greater distance
  - penetrate through objects better
- Antenna size is proportional to wavelength

Frequency	Wavelength	Antenna Size
900 MHz (GSM)	33.33 cm	16.67 cm
2.4 GHz (Wi-Fi)	12.5 cm	6.25 cm
60 GHz (ISM)	5 mm	2.5 mm

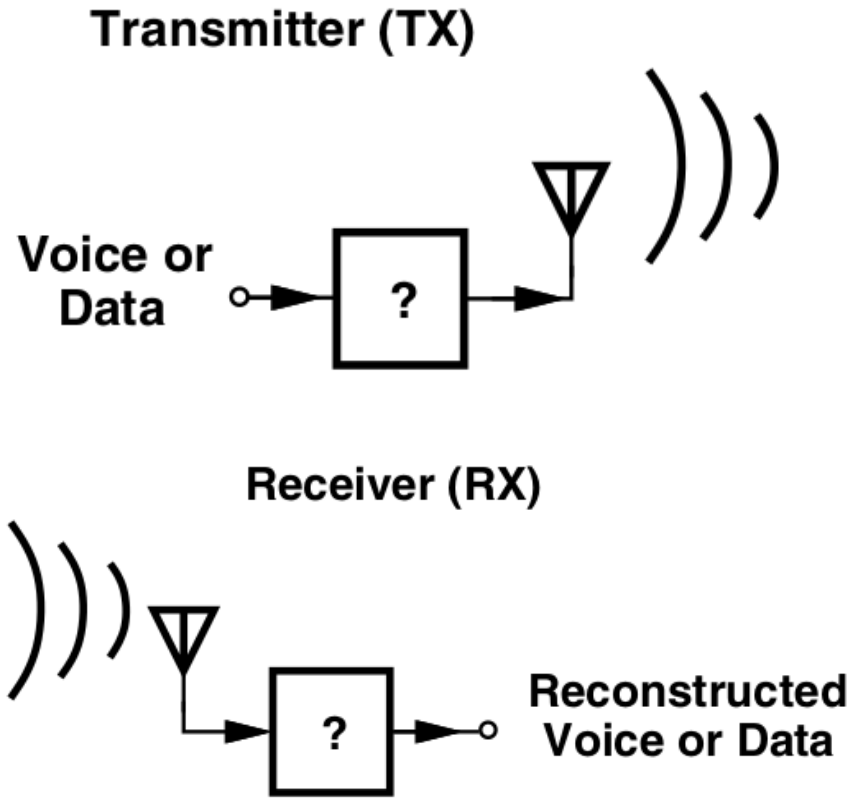
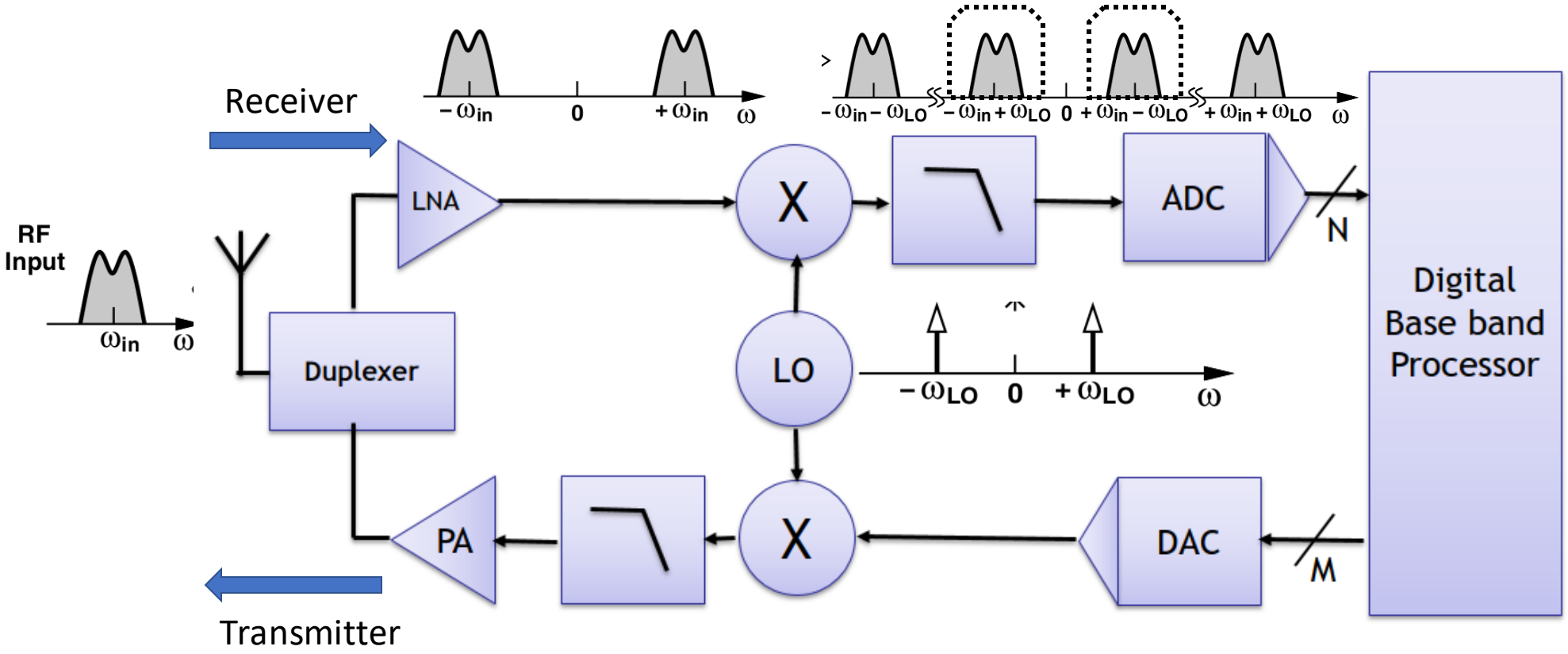


Image Source: RF micro el. Razavi

Transceiver

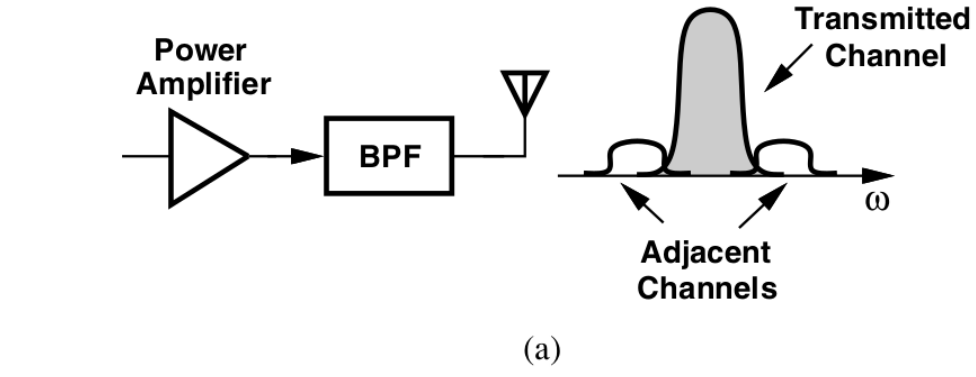
Image Source: RF micro el. Razavi

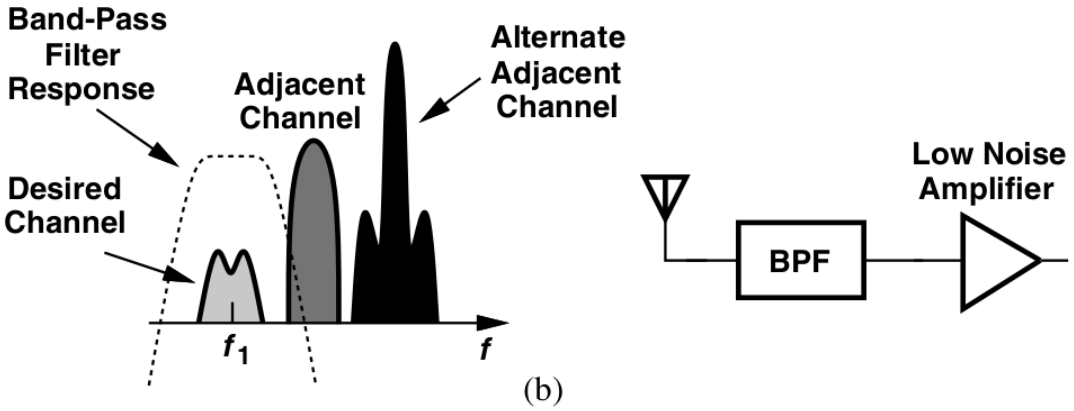


- Higher Frequency --> Smaller Antenna;
- Zero/ Low IF Down conversion ----> Easy Digitization.

Wireless Environment

Receiver not only sees the desired transmitted signal, but much more





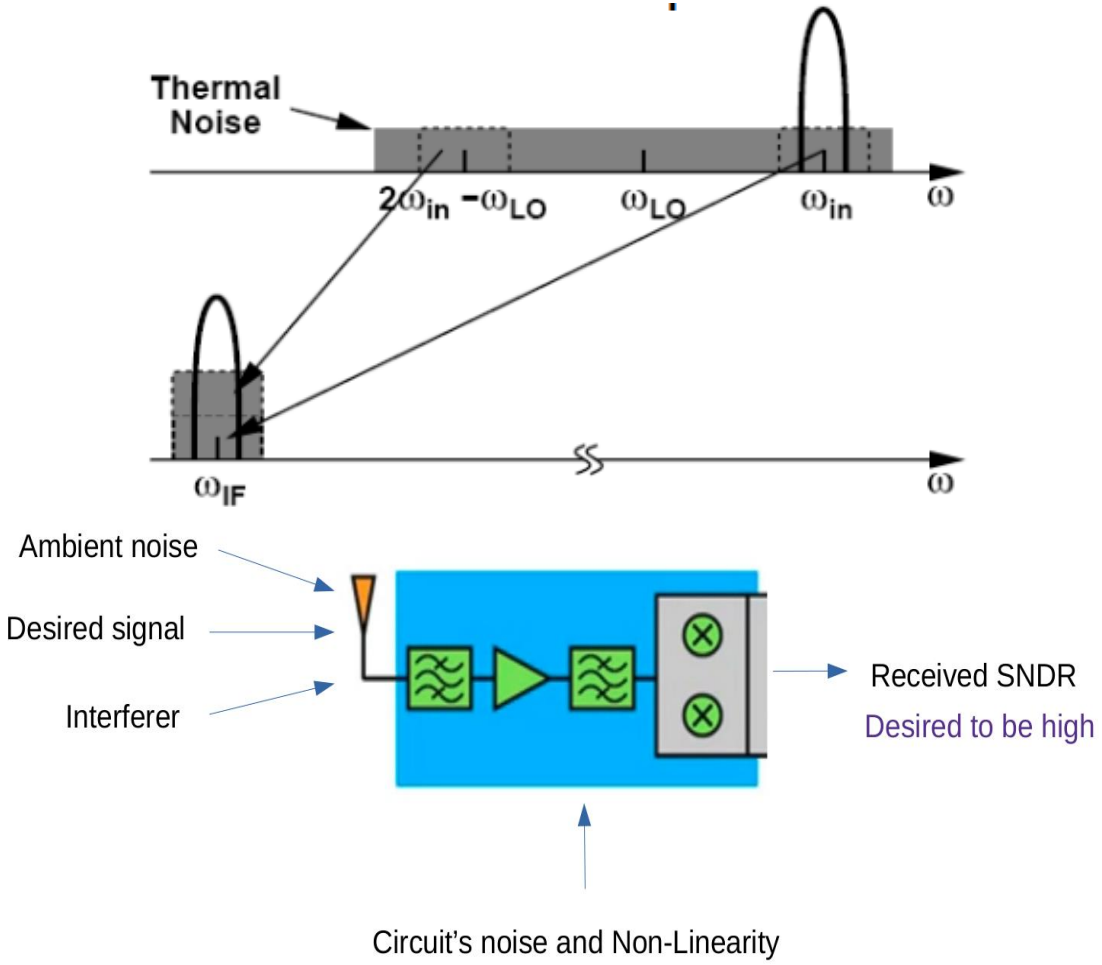
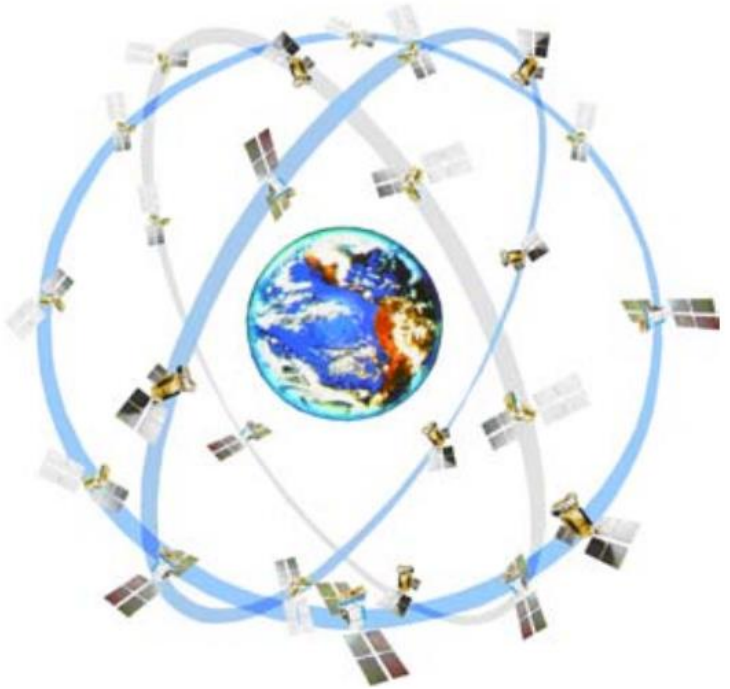


Image Source: RF micro el. Razavi

Navigation Systems

Navigation System	Country	Frequency bands
GPS	USA	L1 - 1.575 GHz L2 - 1.227 GHz
GLONASS	Russia	L1 –1.602 GHz L2 –1.246 GHz
Galileo	European Union	E1 –1.575 GHz E5a – 1.176 GHz E5b – 1.207 GHz
Beidou	China	B1 –1.561 GHz B2 –1.207 GHz B3 – 1.268 GHz
QZSS	Japan	L1 - 1.575 GHz L2 - 1.227 GHz
IRNSS	India	L5 –1.174 GHz S –2.492 GHz

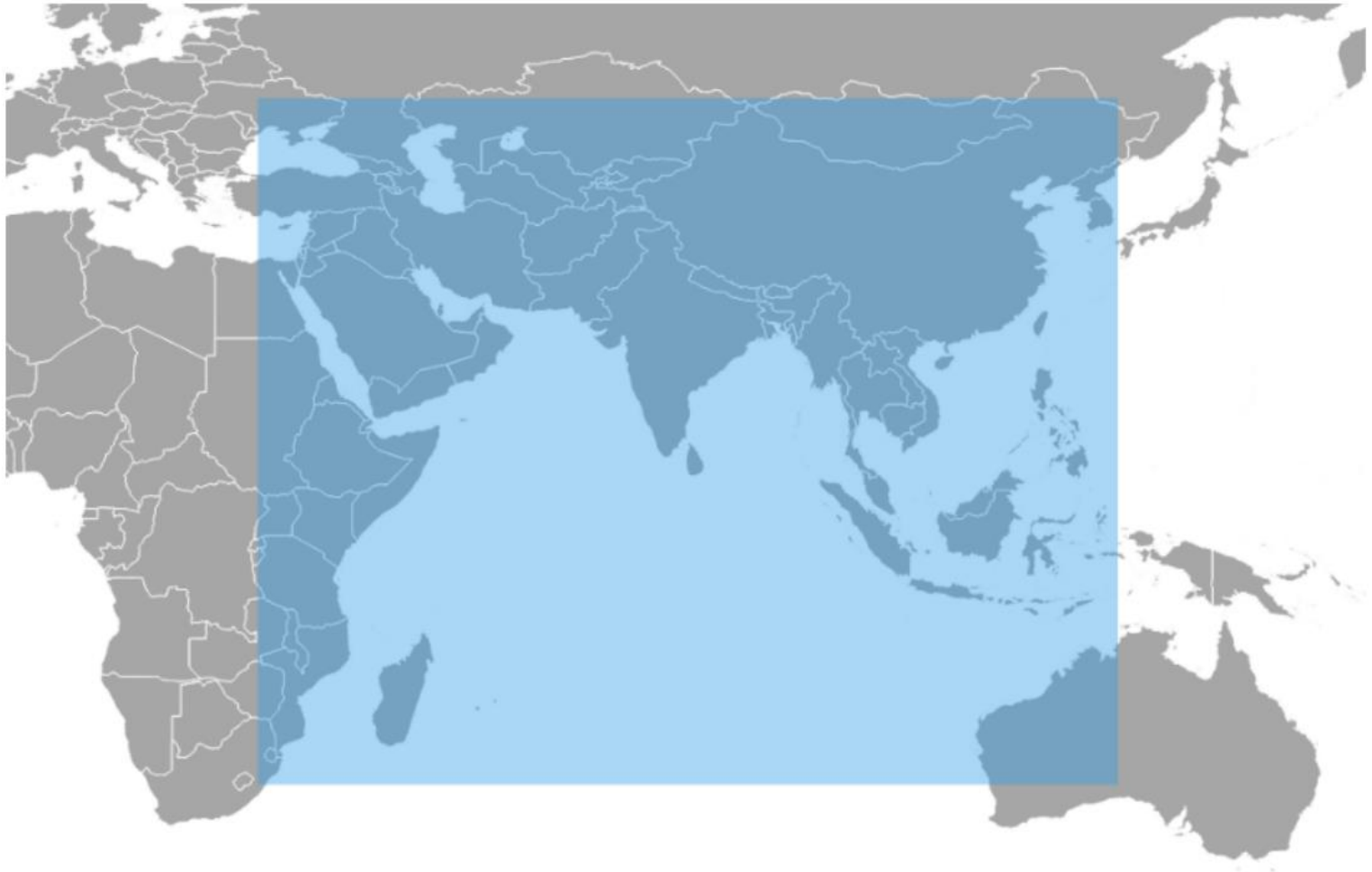


- Interoperability for commercial use
- IRNSS –Regional Navigation Satellite System

Image Source: Gnss e-book

Indian Navigation System– IRNSS coverage

A victory moment - Kargil war 1999



- Can't rely on foreign navigation systems - Self-reliance is necessary
- NAVIC covers up to 1500 KM radius around the country.

Image Source: Wikipedia

Trilateration to find your position

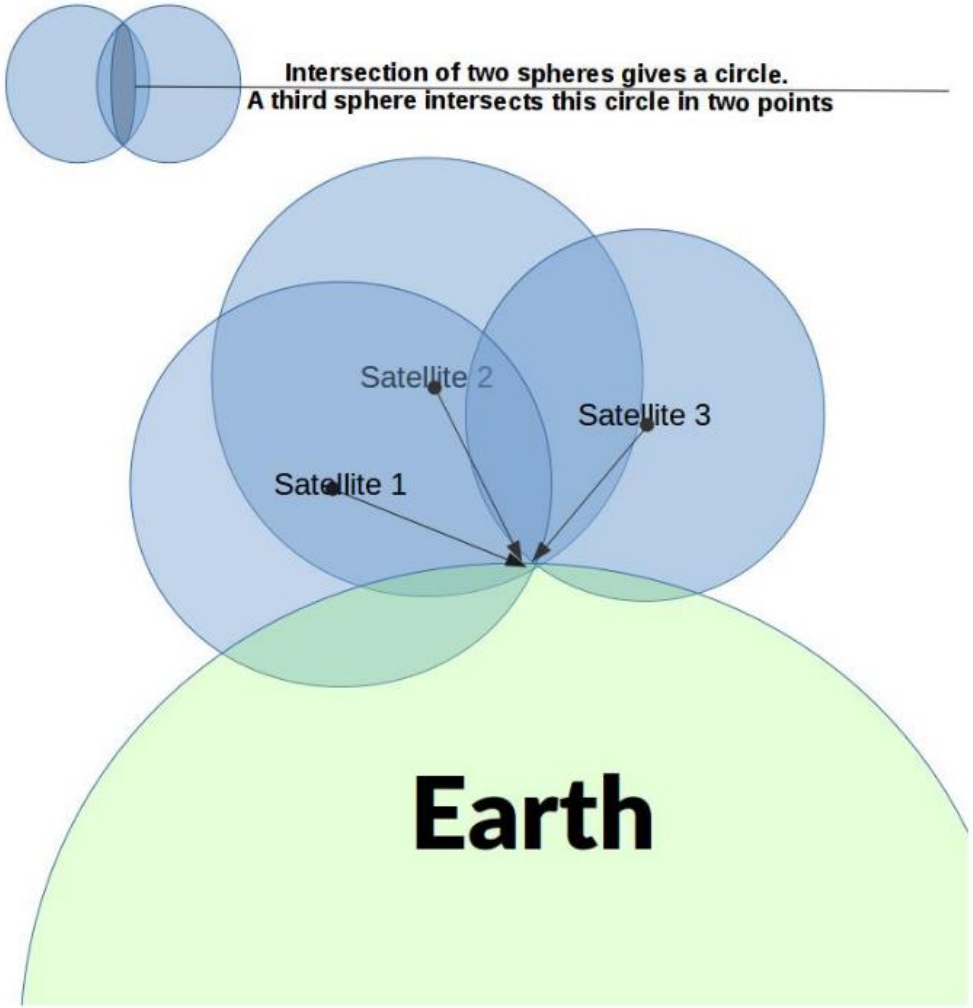
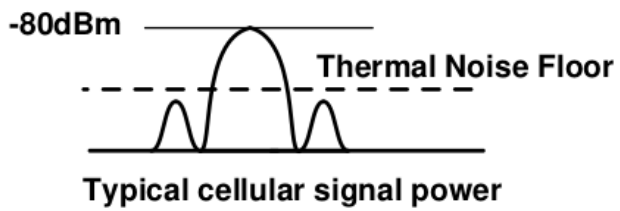


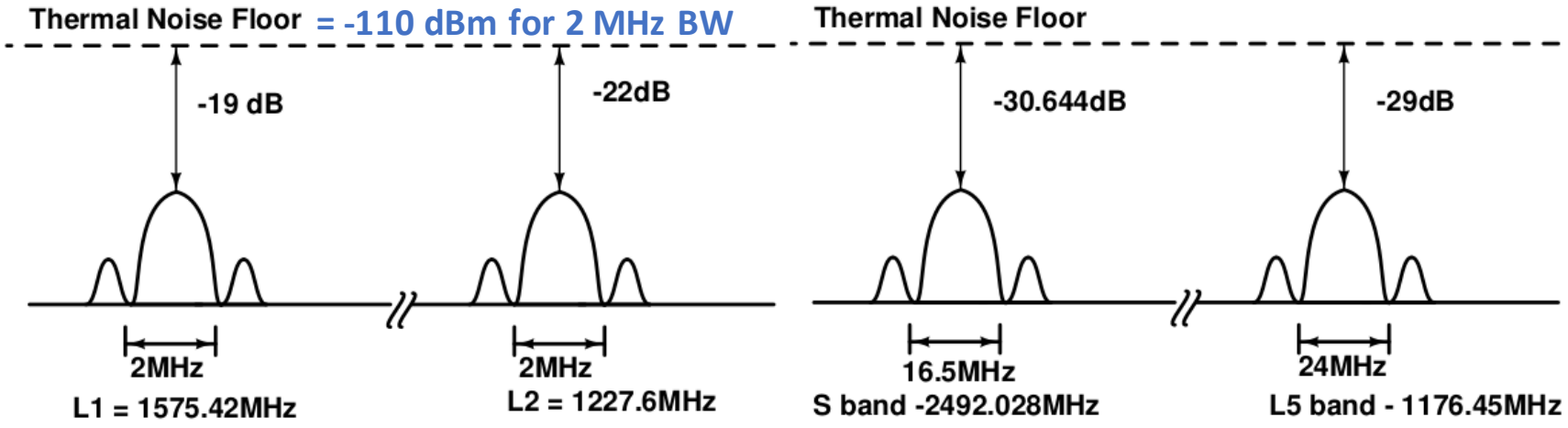
Image Source: Chirag's thesis

- 3 spheres intersect at two points
- One of the intersection in space – to be eliminated
- Assign coordinates to the other intersection
- Four visible satellites for better positioning
- Orthogonal code in high frequency carrier.
- Digital processing on silicon to run algorithm to find location.

Navigation signals & Navigation receivers



- DSP works only if the received signal is available
- A receiver front-end to deals with extremely weak signals – RF front-end for navigation receiver

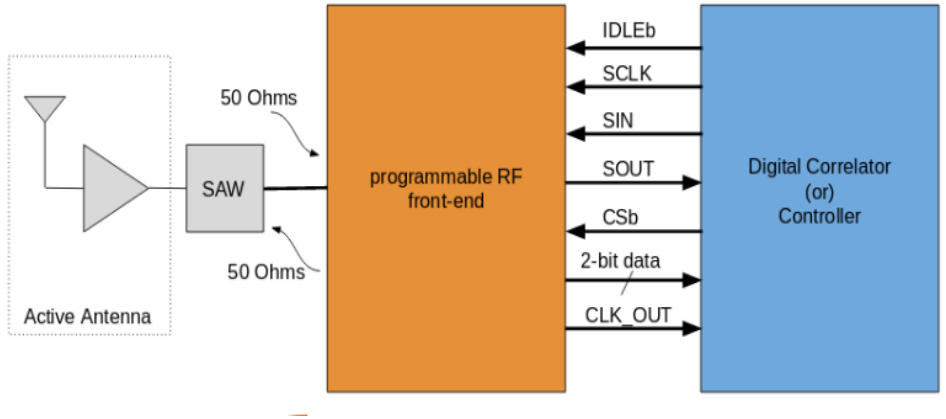


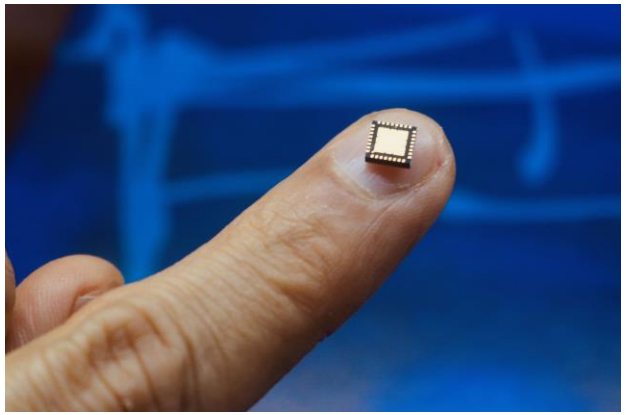
L1 and L2 frequency bands of GPS

L5 and S frequency bands of IRNSS

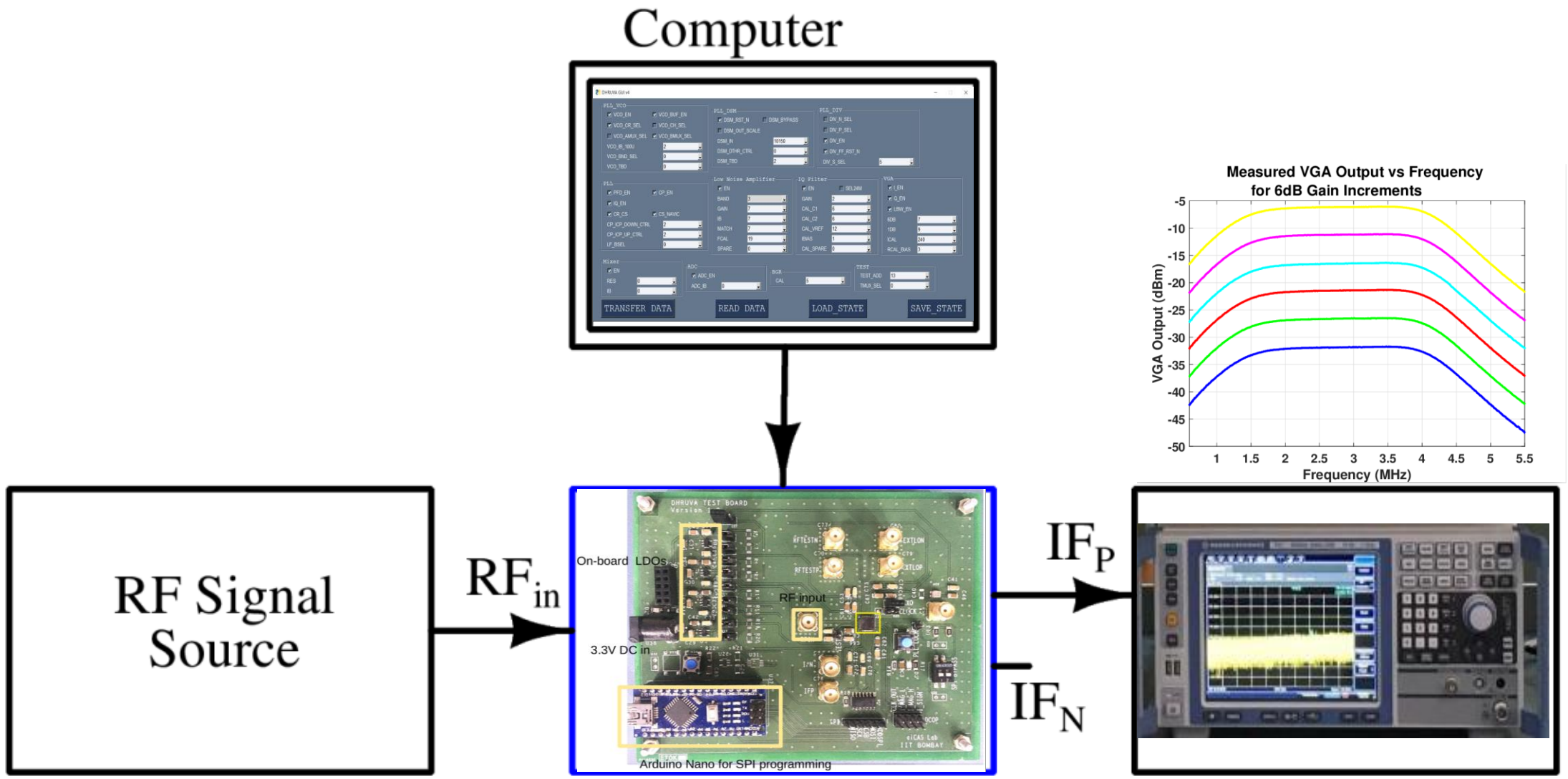
- High gain
- Low noise addition
- Controllable gain
- Stable Local oscillator
- Low power consumption
- Easy integration into SoCs

Dhruva – A Multi-band Navigation Receiver

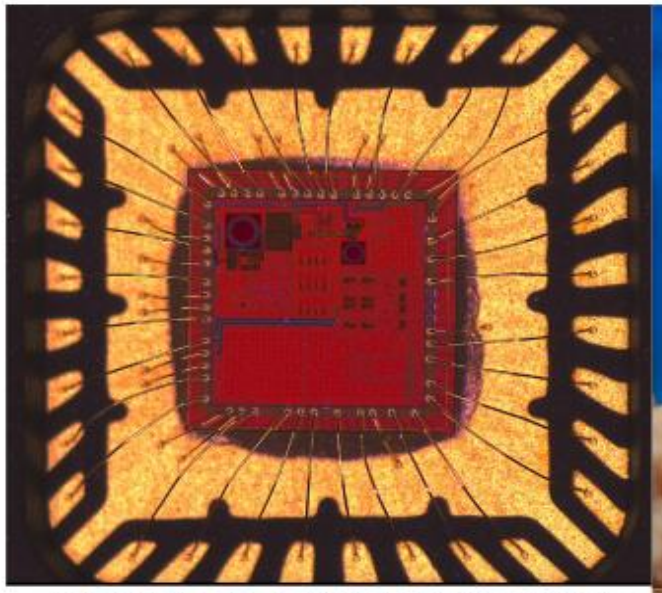


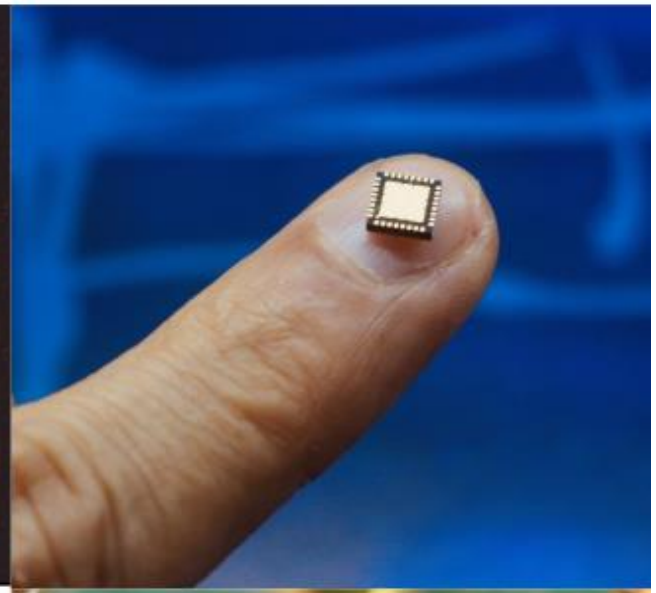


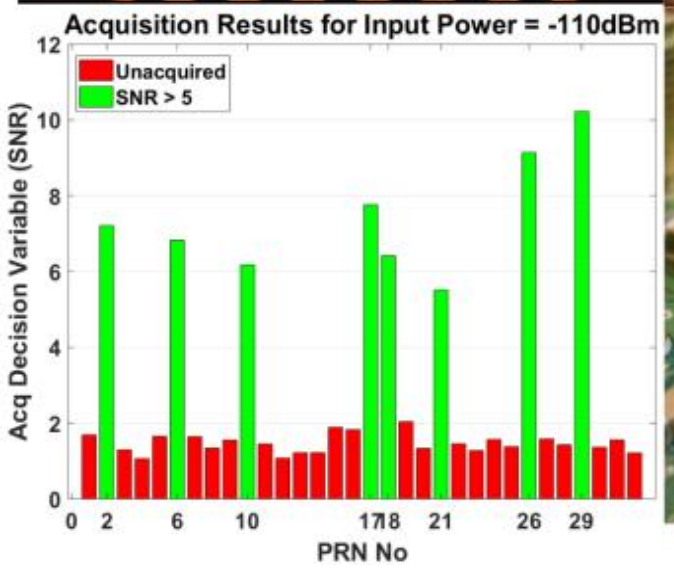
Silicon under test

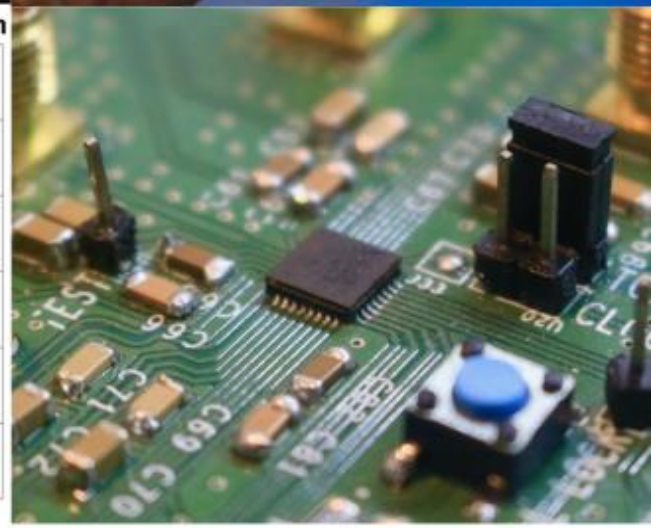


Dhruva






Acquisition Results for Input Power = -110dBm
Unacquired
SNR > 5
Acq Decision Variable (SNR)
PRN No
0
2
4
6
8
10
12
0
2
6
10
17
18
21
26
29



Dhruva 2.0

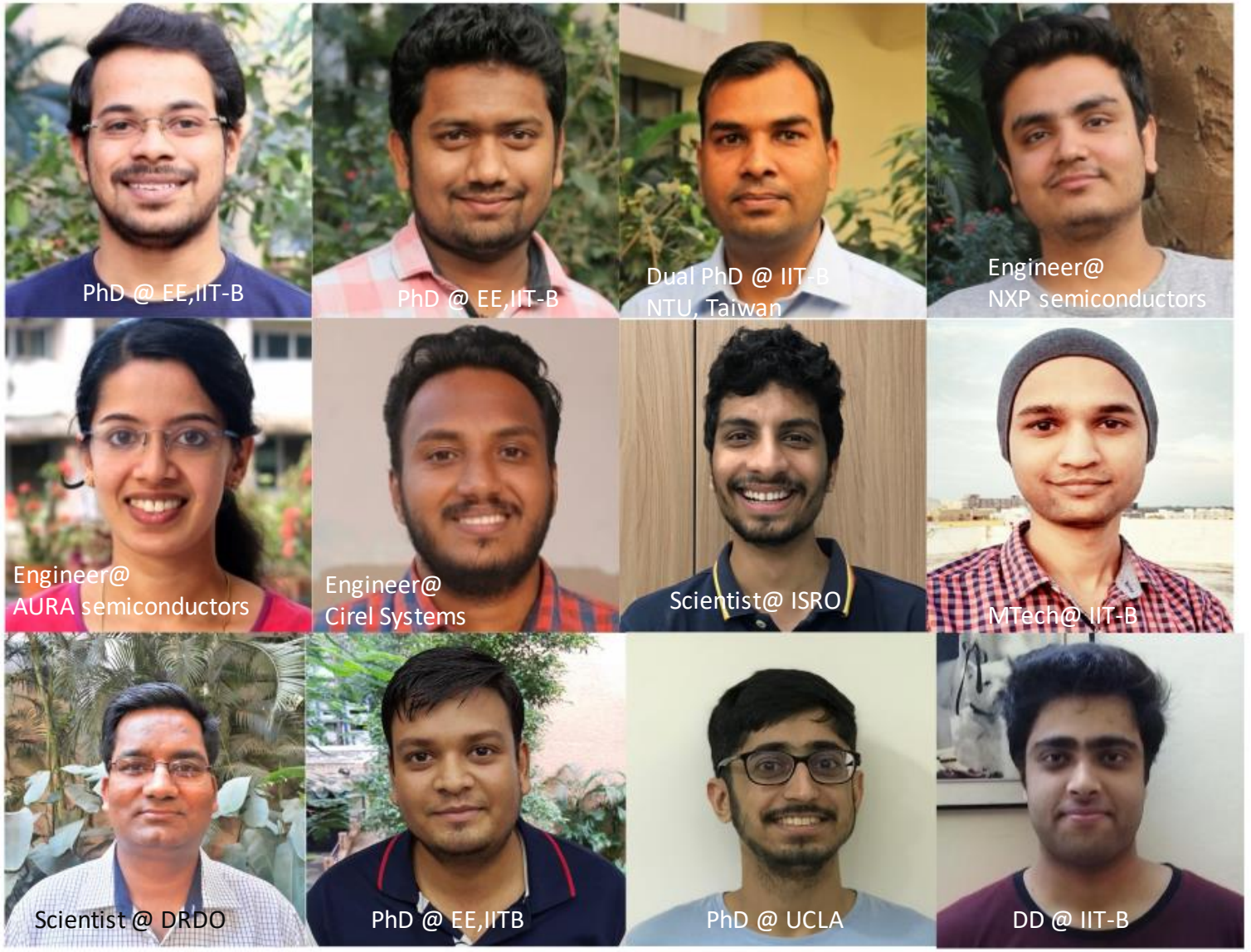
Going Forward :

- An advanced version with more features on-chip
- Substantial smaller footprint

How can Dhruva help India ?

- Accurate commercial positing services with IRNSS or other navigation systems.
- Vehicle tracking - Soon, you will find IRNSS guiding your driver to destination.
- Made in India – Must give an advantage in many aspects.

Dhruva Team


PhD @ EE,IIT-B
PhD @ EE,IIT-B
Dual PhD @ IIT-B
NTU, Taiwan
Engineer@
NXP semiconductors
Engineer@
AURA semiconductors
Engineer@
Cirel Systems
Scientist@ ISRO
MTech@ IIT-B
Scientist @ DRDO
PhD @ EE,IITB
PhD @ UCLA
DD @ IIT-B

Thank You