BEST NASA

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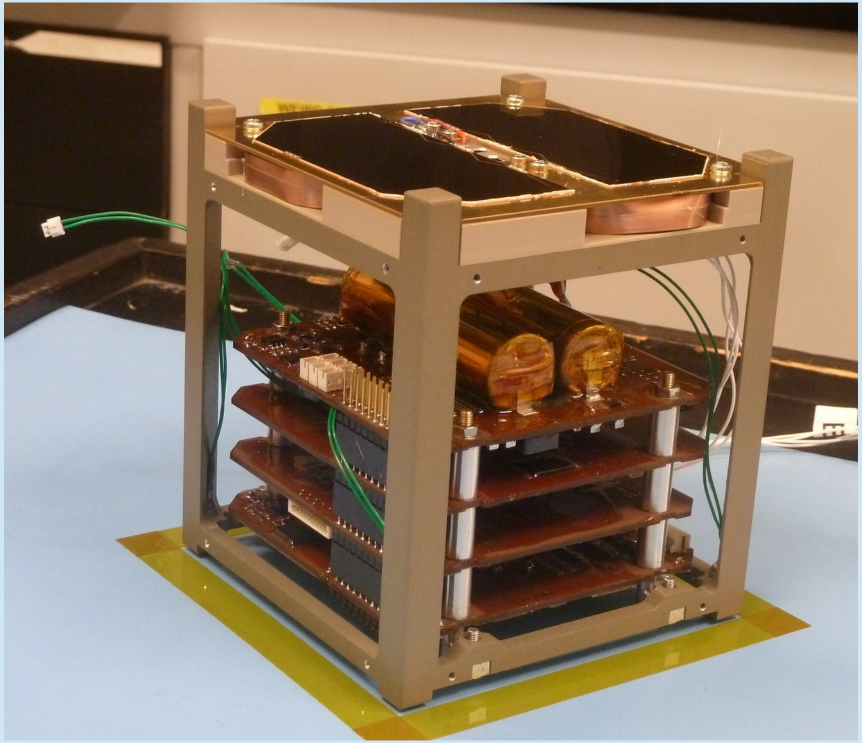
AAU Satlab

Who/What - Are AAU Satlab?

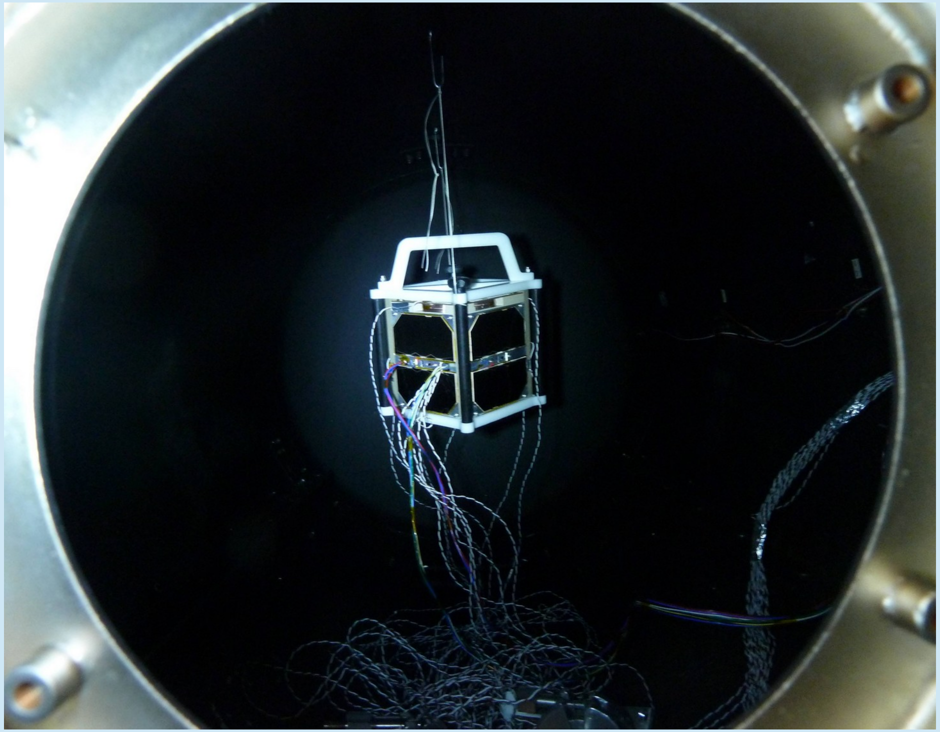
Who/What - Are AAU Satlab?

- Designed and built at AAU!
- Tasks suiting every interest.
  - Antennas
  - BMS/Power supply
  - Radio
  - Control systems
  - Mission Control / Ground station
  - Payload(s) and more!



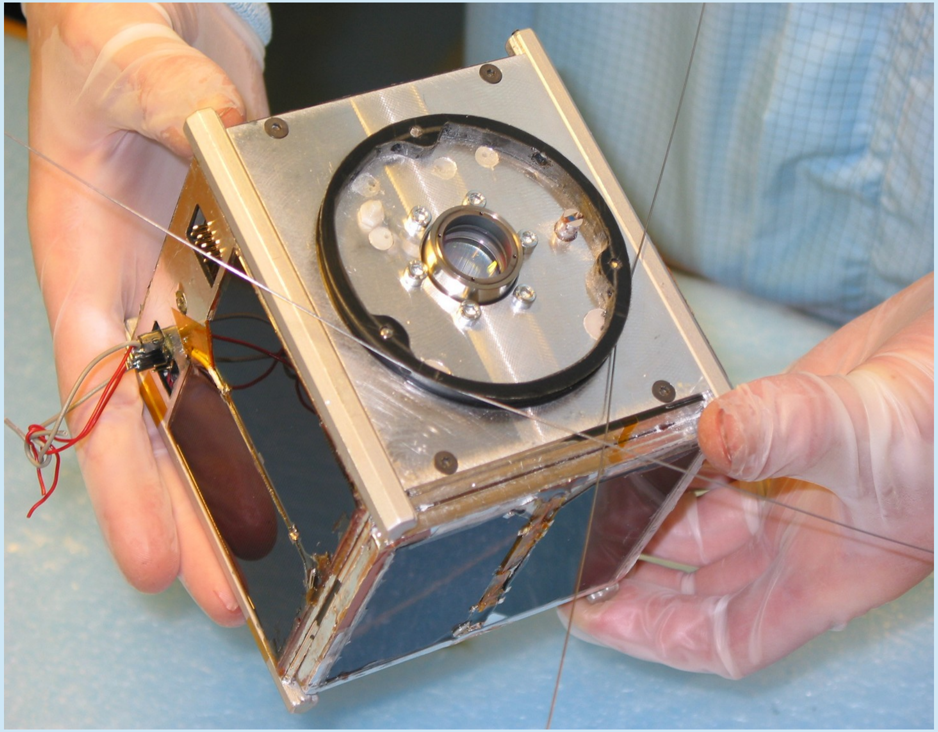
Who/What - Are AAU Satlab?

- Long-Term project!
  - Target launch 2026
- Being a part of the whole process!
  Design → Launch → Contact
- Gain relevant experience to work in the space sector!



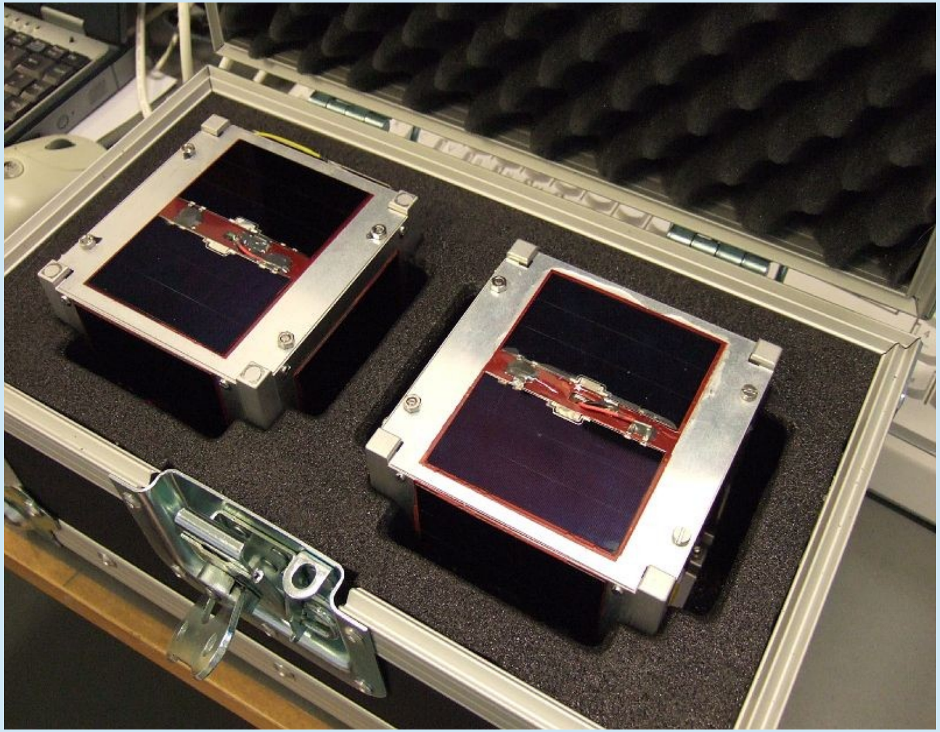
AAUSAT1

- 2001 – 2003
  Launch 30/6 – 2003
- **Goals:**
  - Education
  - Earth observation through camera.



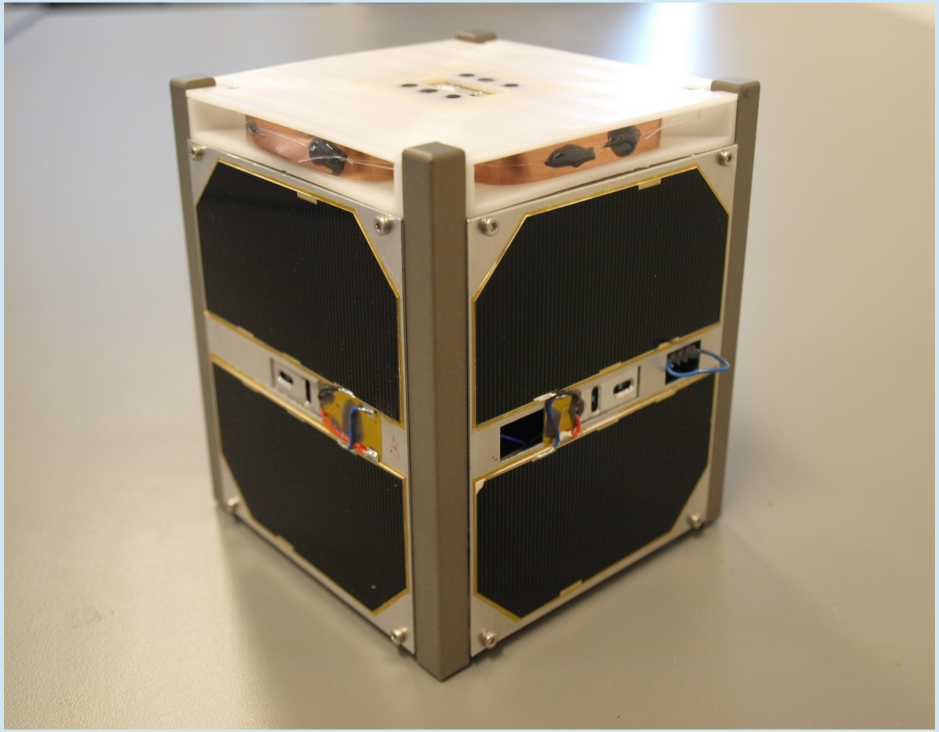
AAUSAT2

- 2003 – 2009
  Launch 28/4 – 2008
- **Goals:**
  - Education
  - Gamma ray detector
  - Improved Radio and ADCS



AAUSAT3-5

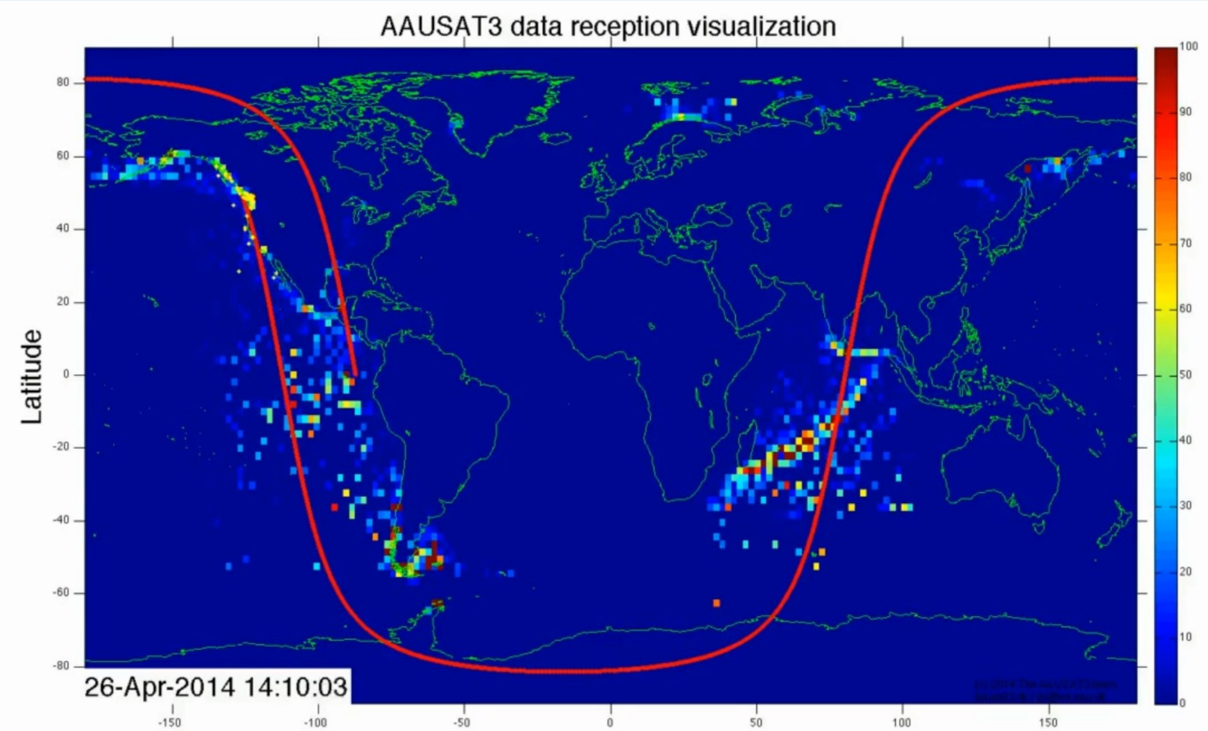
- 2007 – 2014
  Launch 25/2 – 2013
  - AAUSAT5: 5/10 - 2015
  - AAUSAT4: 25/4 - 2016
- **Goals:**
  - Education
  - AIS Detection
  - Improved Radio and ADCS



AAUSAT3 -5

Data illustration

- AAUSAT3
  - 800k messages in first 100 days



AAUSAT6

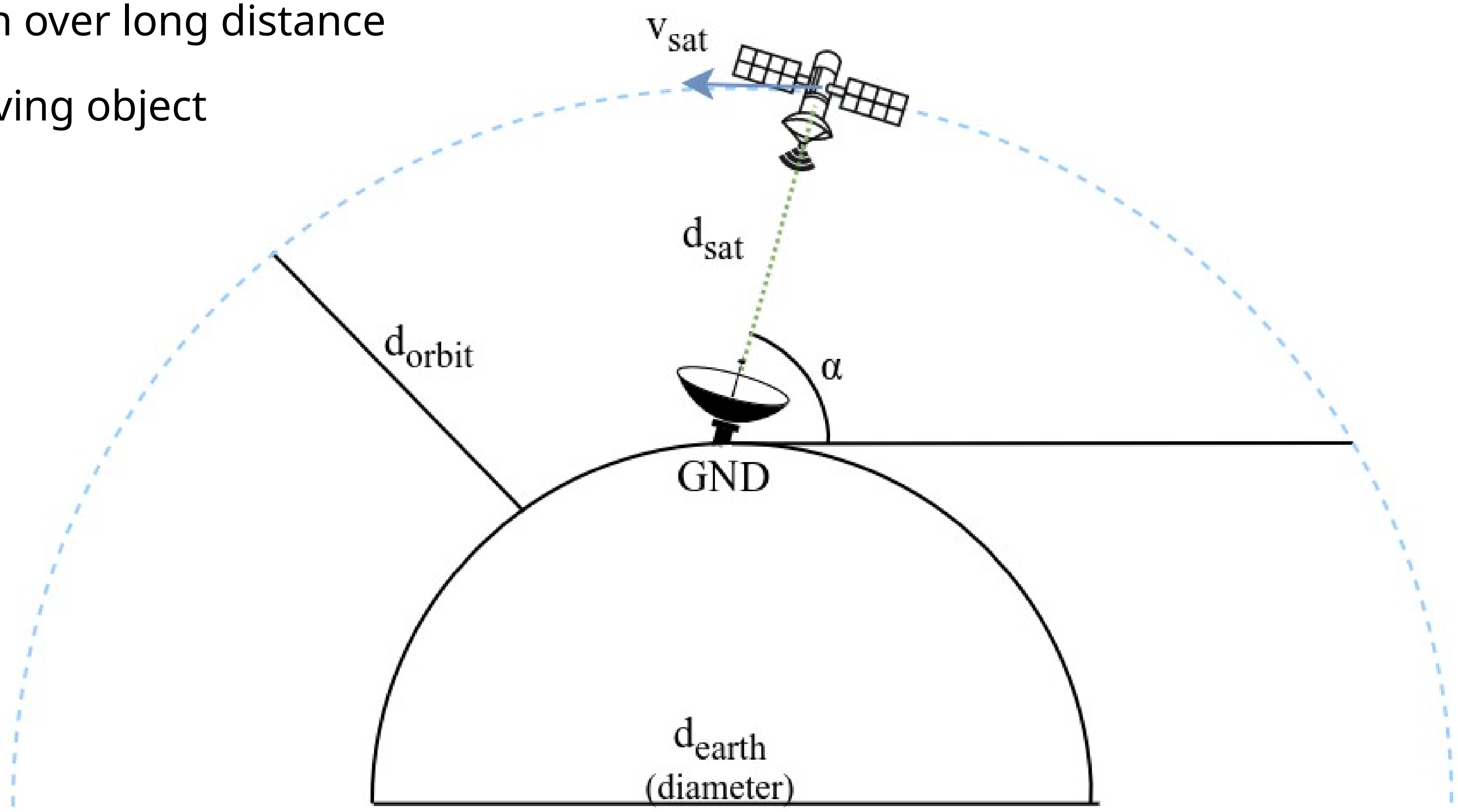
- 2022 -
  Launch: Target Q1-Q2 2026
- **Goals:**
  - Education
    - Experimental platform
    - SDR
  - Earth Observation w. Optical camera.
    - Enable video streaming, with feature tracking.
  - Improved ADCS
  - Improved High and low speed radio.

Questions?

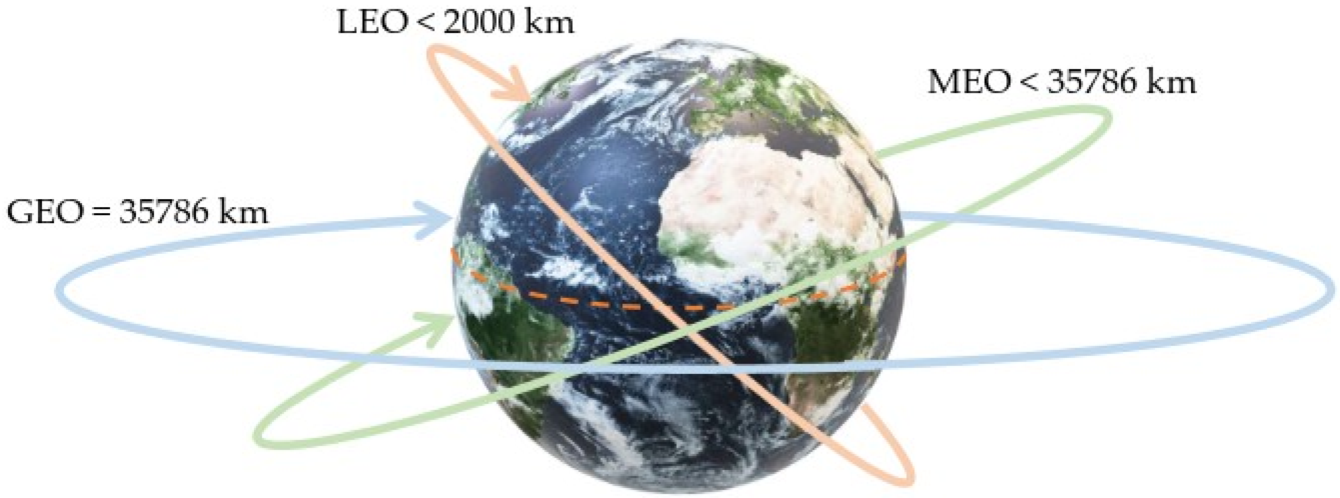
Satellite Communication

The problem

- Communication over long distance
- Tracking of moving object
- Large latencies



Orbits

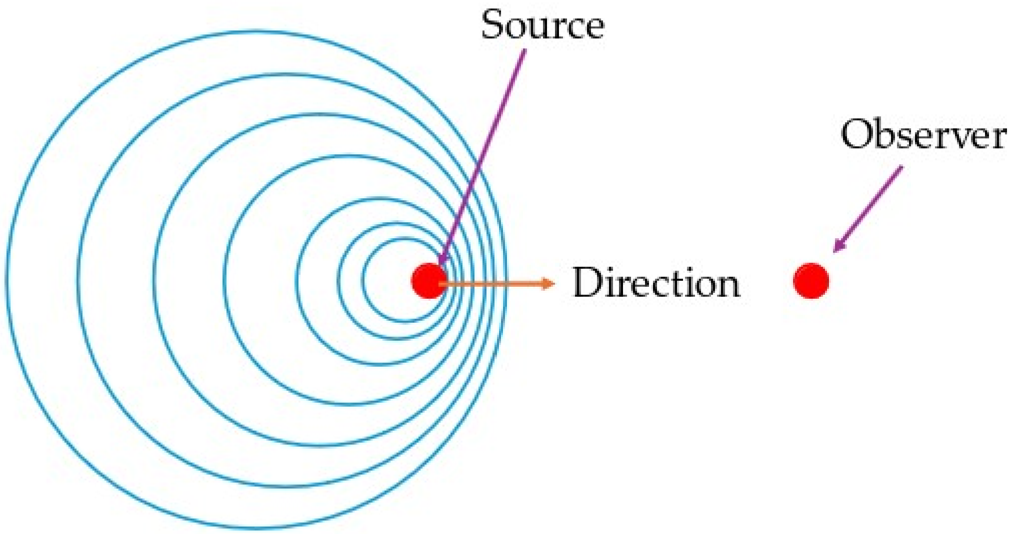


Doppler Effect

- Change in frequency, in relation to the observer.
- For a stationary observer:

$$f = \frac{c}{c \pm v_s} f_0$$

f – observed frequency
c – Speed of light
v_s – Velocity of source
f_o – Frequency at source



Doppler Effect - Impact

- Impact, for a satellite in 550km orbit
- Larger impact for higher frequencies.
- How to handle doppler?

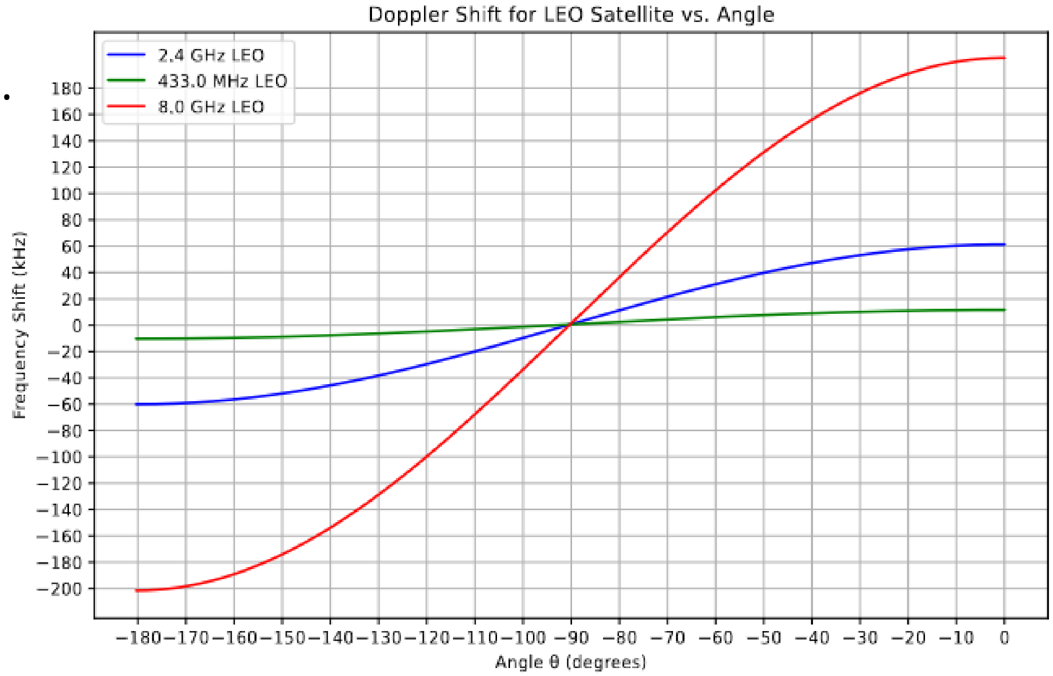
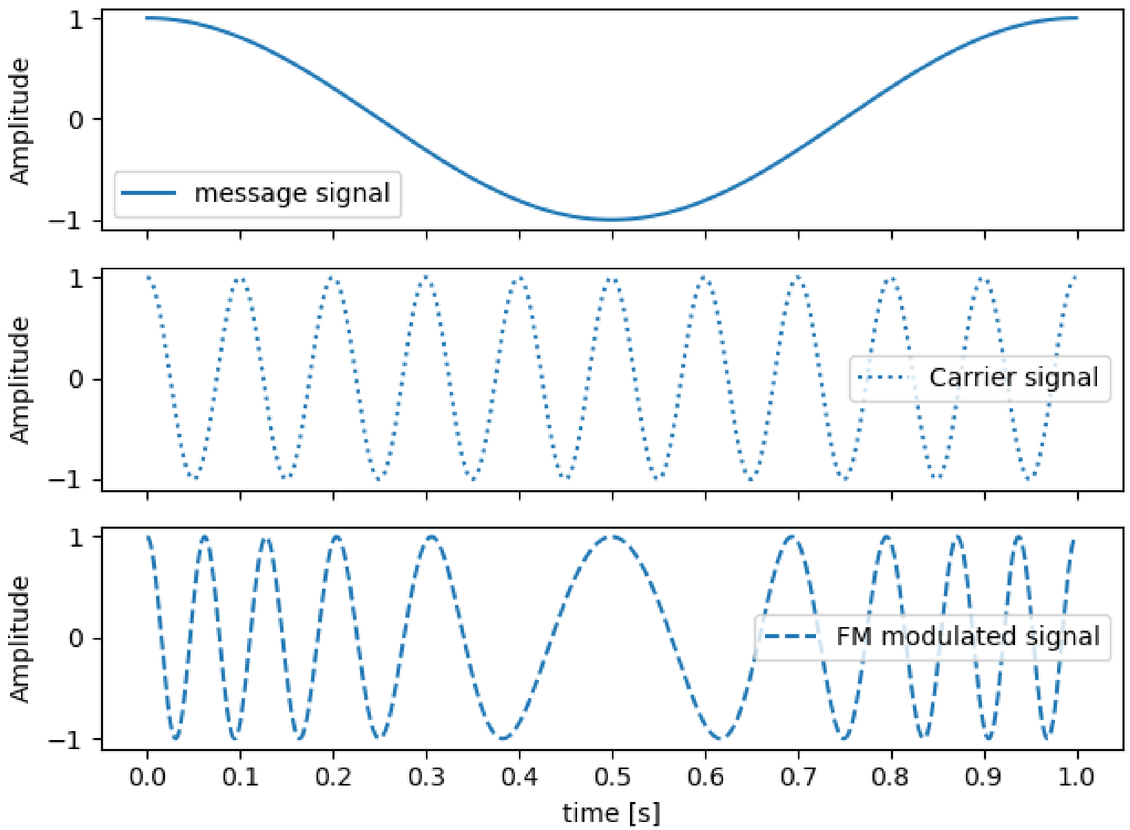


Figure 2.5: Plot of Doppler shift for different frequencies at a velocity of 7.59 km/s.

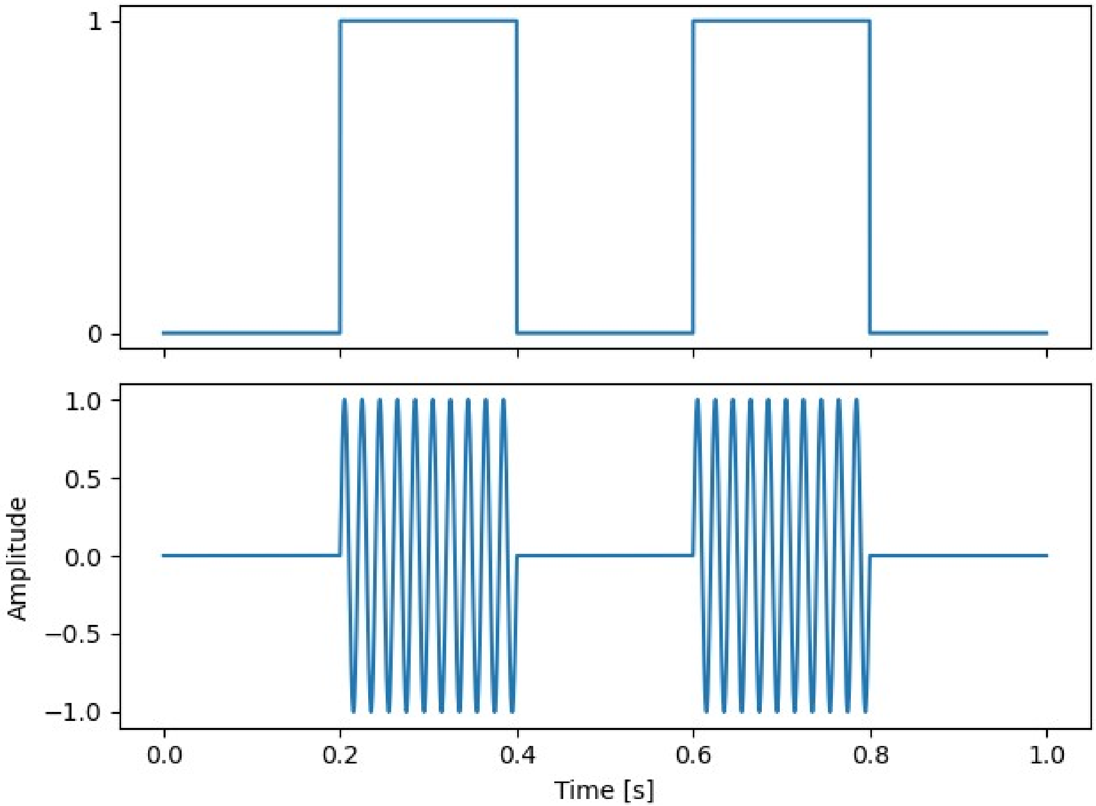
Modulation - FM

- Analog message
- Frequency of carrier changes with amplitude of message
- How do we transmit digital data?



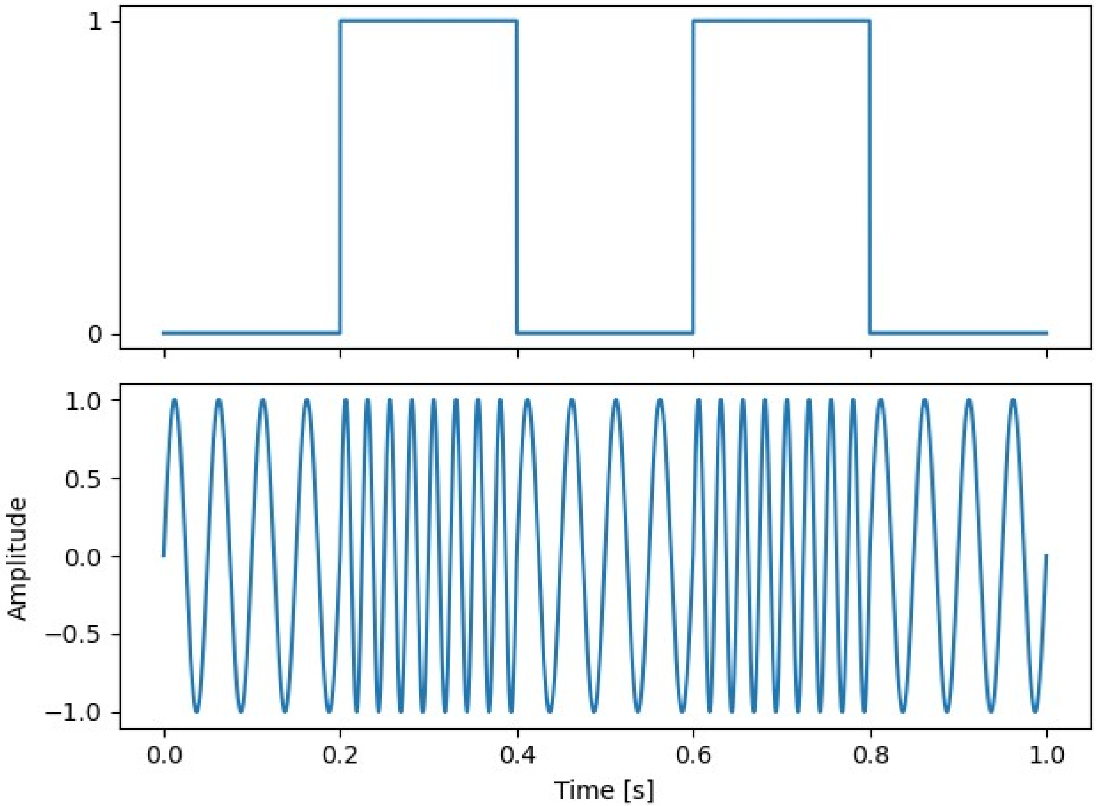
OOK – On off keying

- Constant amplitude
- Turning on and off PA



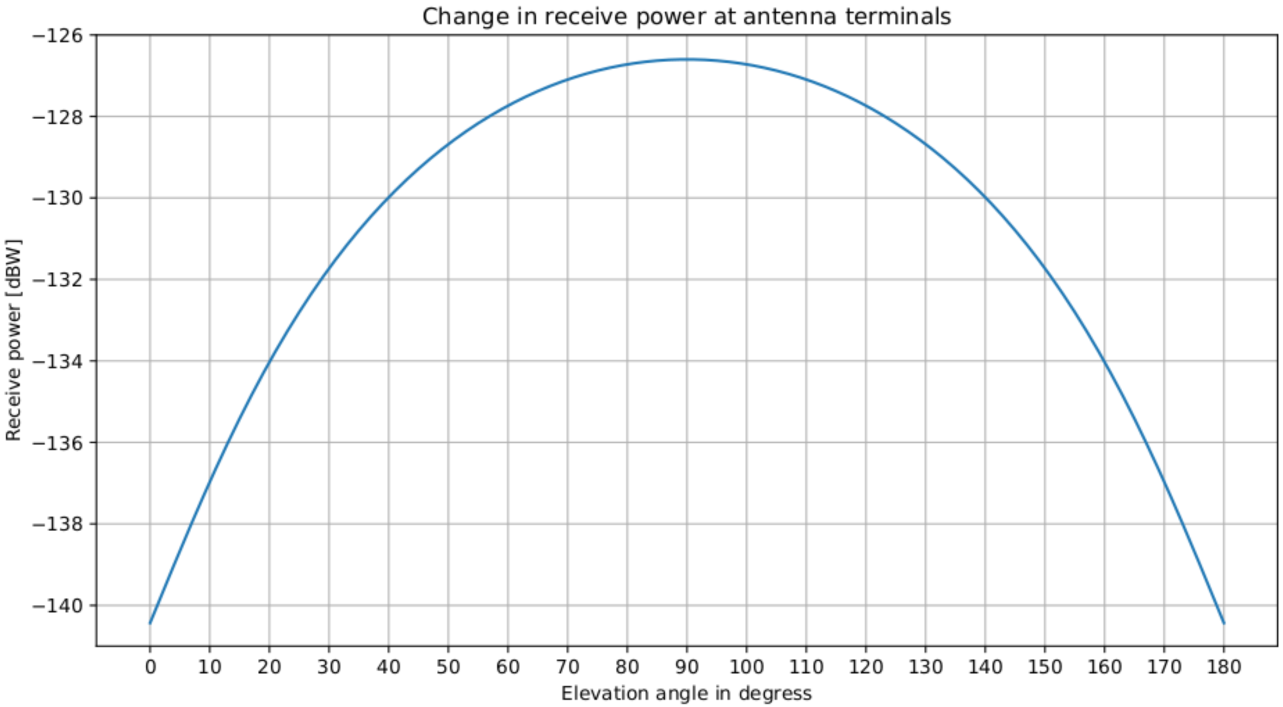
FSK – Frequency Shift Keying

- Encodes data by changing freque
- 0 – Space
- 1 – Mark



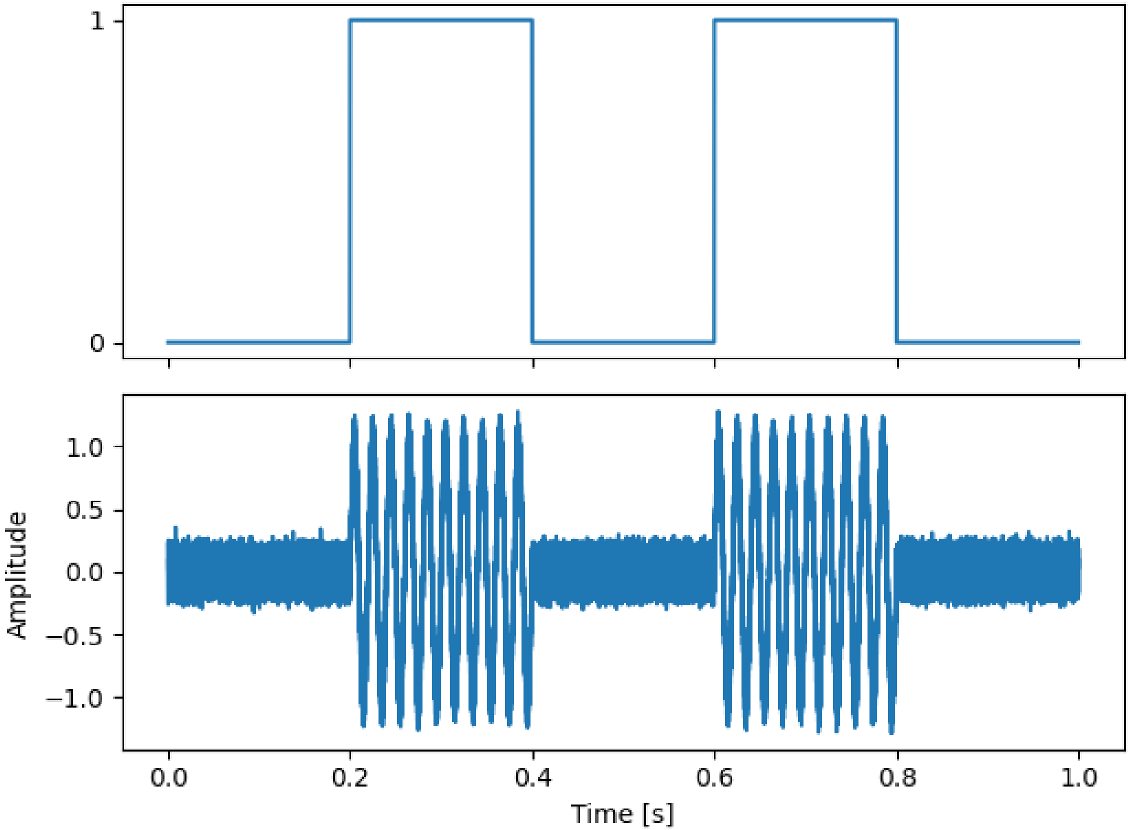
Reception

- Large losses in signal strength
- Noisy channel
- Picture - approx:
  0.01 to 0.2 [pW]



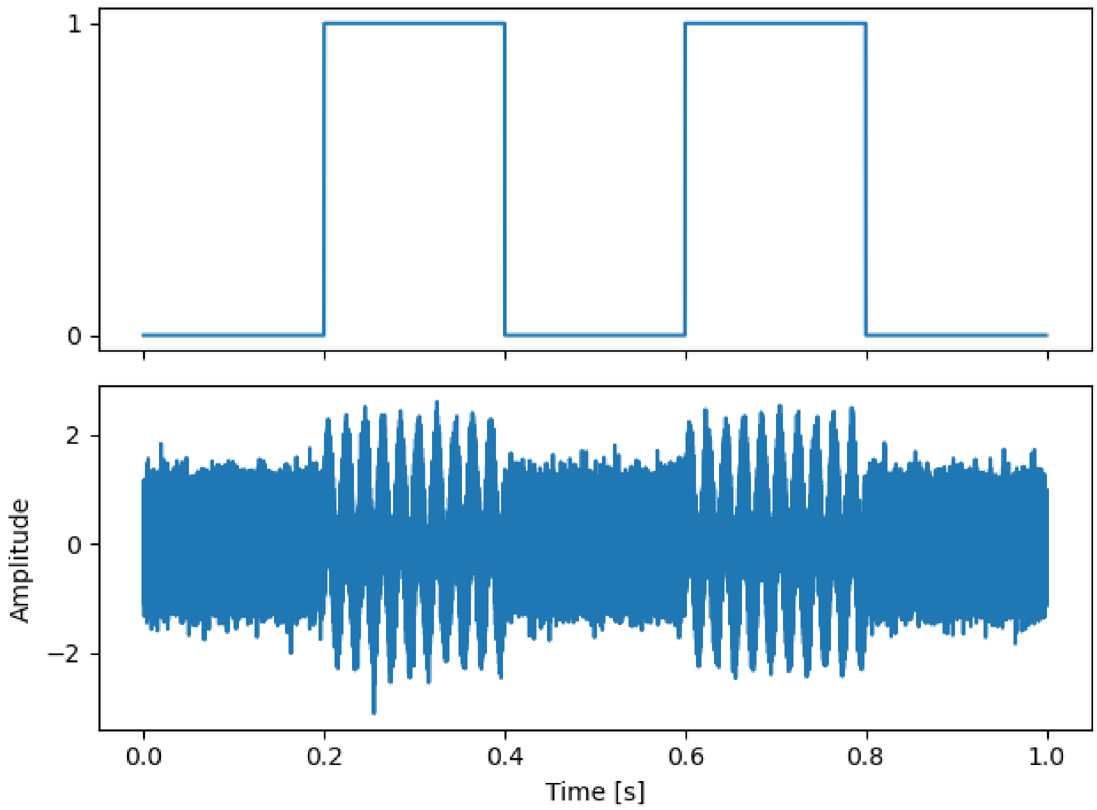
AAUSAT GND – UHF receive power

Noise



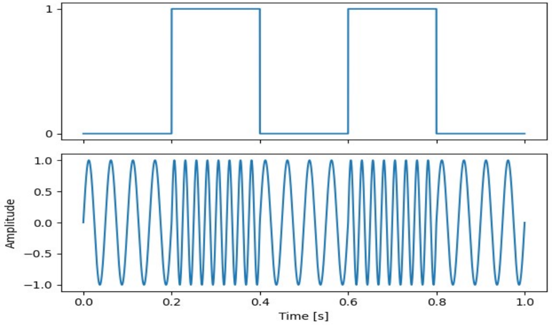
Noise

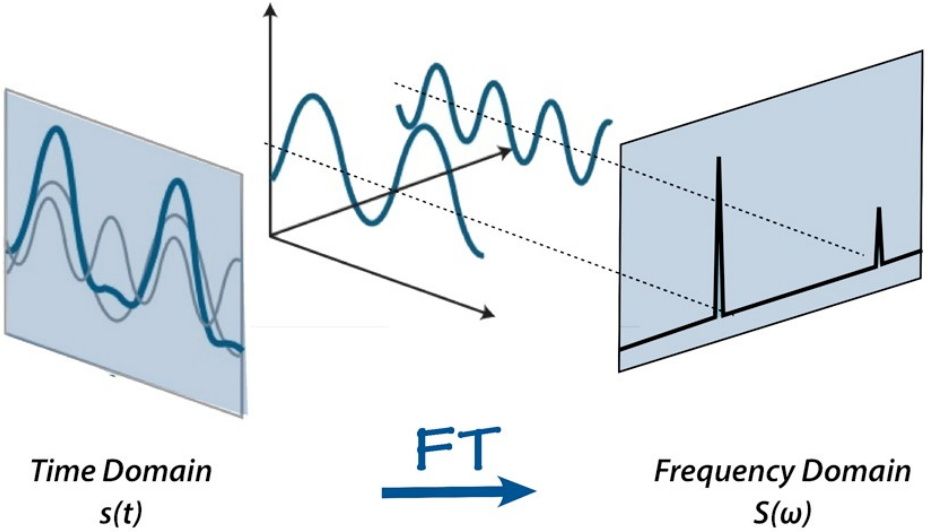
- Introduces bit erros as it is harder to distinguish, between 0 or 1.
- Redundancy in messages most be introduced.



Time and frequency domain

- Joseph Fourier
- Any function can be expanded into a series of sines.

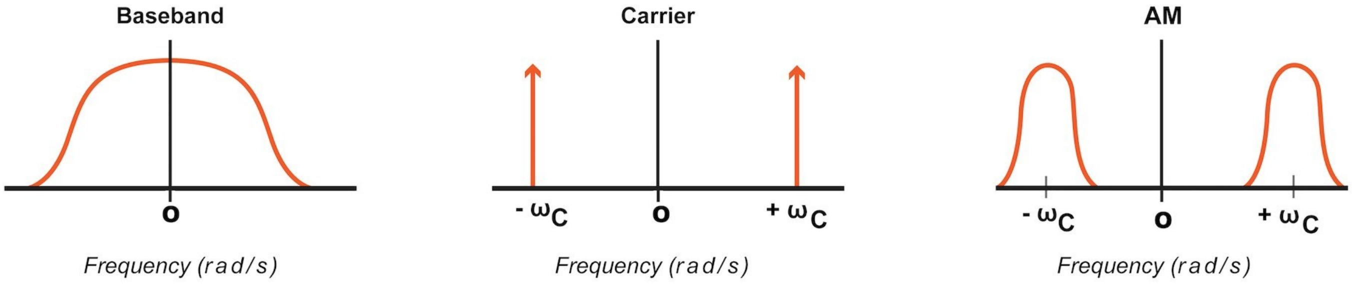




©Medium Fourier Transform

Baseband and RF

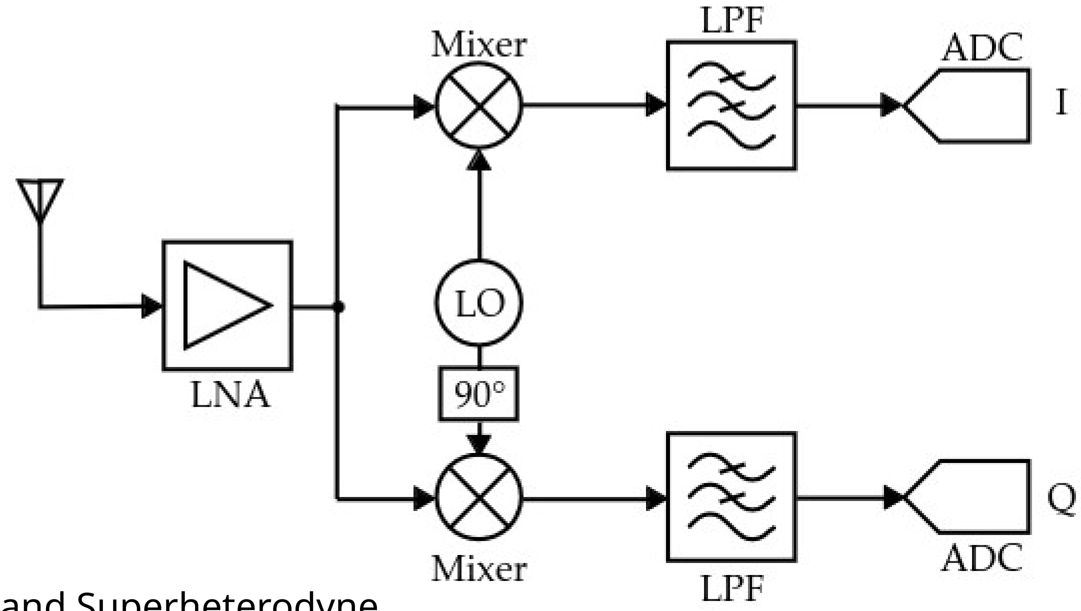
- Modulated message is generated in baseband
- Baseband is then moved to the carrier frequency



SDR – Zero-IF

- SDR – Software Defined Radio
  IF – Intermediate frequency

- Recover baseband from carrier
- Split baseband into I/Q



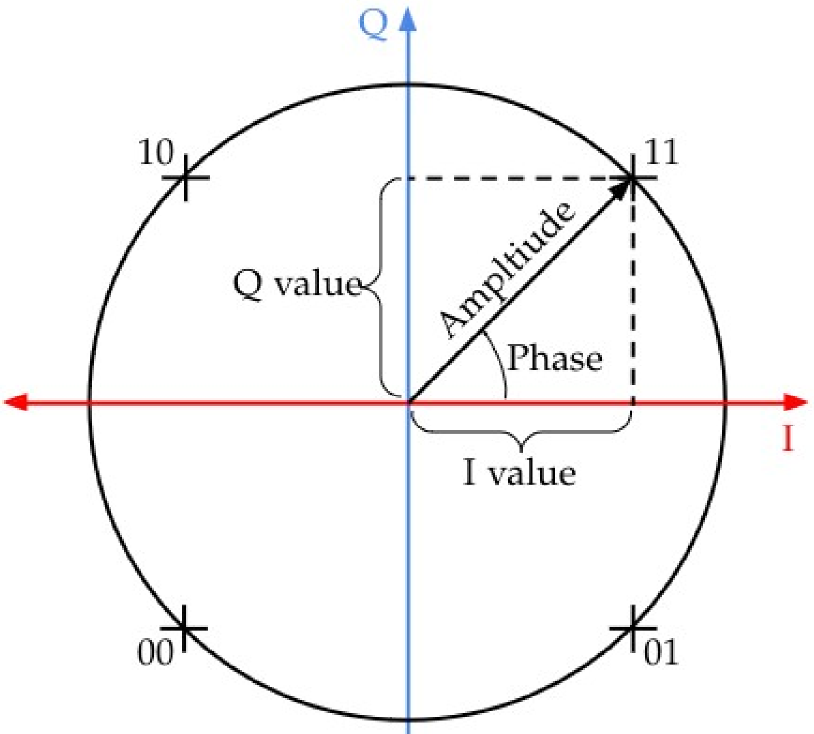
- Other architectures are Heterodyne and Superheterodyne
  - One or more intermediate frequencies

SDR – I/Q

- I – In-phase component
- Q - Quadrature component

- Can describe the complex plane

Note: Amplitude/Magnitude for workshop



QPSK – Example

Demodulation

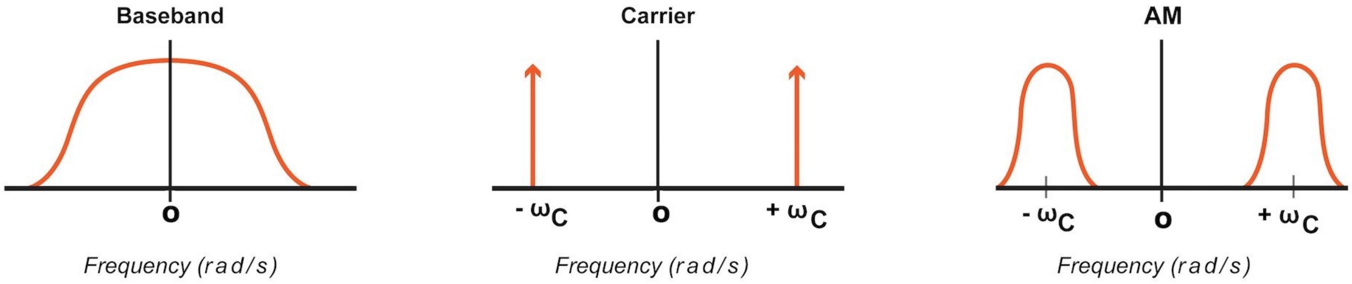
- Demodulation is harder than modulation
  - Why?
- Time!
- Transmitter and Receiver must be synchronized.

Demodulation

- We need:
  - Carrier sync
    - (Phase sync)
  - Symbol sync
  - Frame/Bit sync

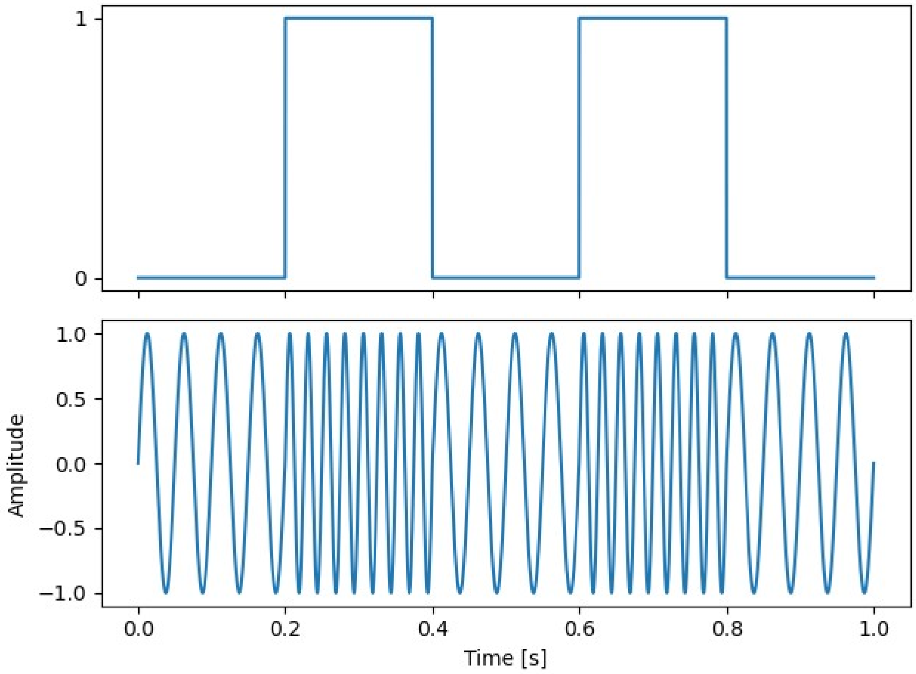
Carrier Recovery

- Fll – Frequency locked loop
- PLL – Phase locked loop



Symbol Sync

- Recover timing
- Potential error sources are:
  - Discrepancies in clock
  - Quantization errors in baseband



Frame/bit Sync

- Need to match computer memory architecture
- Use of frame sync markers (FSM)
- Sequence can be shifted across bytes: („OZ“)
  - 01010100 | 11110101 | 10101110

Radio bands

- Typically used in amateur satellites:
  - VHF (144-146 MHz)
  - UHF (435-438 MHz)
  - S-band (2400-2450 MHz)
  - X-band (10.45 – 10.5 Ghz)
- Band limitations

Why use SDR's?

- High flexibility
  - „Just“ change the program for another radio
- Connect your systems, with amateurs around the world.
  - Satnogs

- Cons
  - Slower than hardware defined radio
  - Design from scratch

Workshop

- Task 1:
  - Familiarize with GnuRadio, play around with the spectrum and create a FM receiver. (98.1MHz has a channel) – Can you find more? Where?
    - Play music through a \`Audio Sink\`   (Hint: sample rate must match)
- Task 2:
  - Decode the OOK message morsed at 437.225 MHz
    - Play it through a \`Audio Sink\`, is it a clean sine wave?
      If not, how can you clean it up?
- Task 3:
  - Decode the FSK modulated signal at 437.1 MHz with a symbolrate of 960 symbols/s
  - Message structure is: | 100B 0x55 | Message | 100B 0x00 |
    The message is ASCII encoded starting with \`C\`