Karlsruher Institut für Technologie

Institut für Technik der Informationsverarbeitung

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Institut für Technik der Informationsverarbeitung (ITIV)

Communication Systems and Protocols

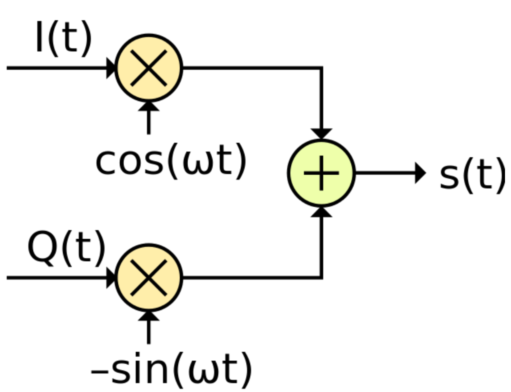
Exercise 1

Task 1:
Quadrature Amplitude Modulation

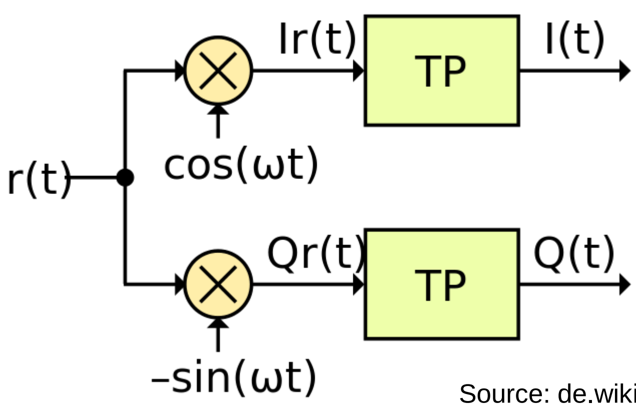
Quadrature Amplitude Modulation (QAM)

- Usage of two sine carrier signals that are shifted 90° to each other
  → Signals do not interfere with each other
  - One signal is called *In-phase component (I)*
  - Other signal is called *Quadrature Component (Q)*
- These two signals are added up to form the sender signal *(IQ-Modulation)*
- Demodulation requires same phase in sender and receiver → additional measures required

QAM-Modulation



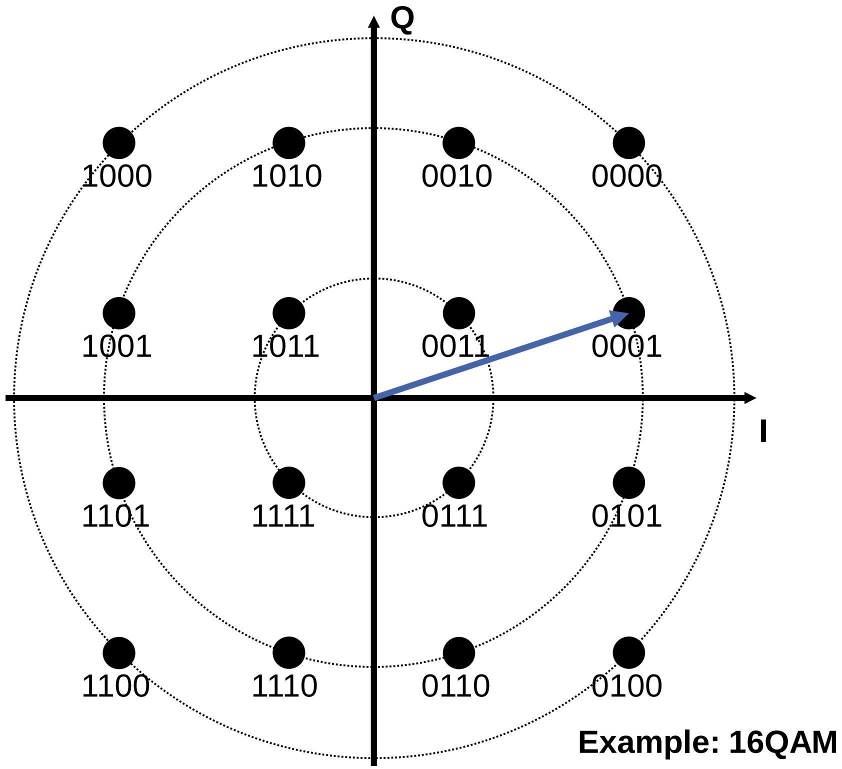
QAM-Demodulation



Source: de.wikipedia.org

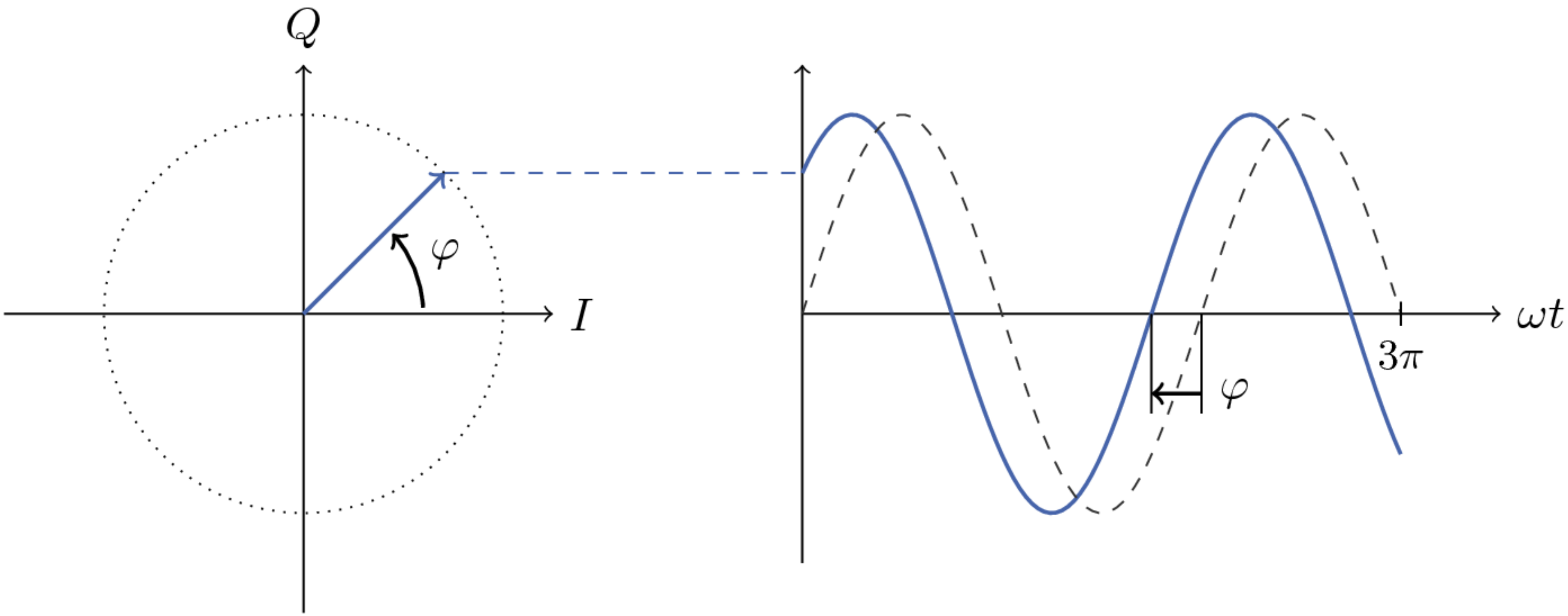
Quantizied QAM: Constellation diagram

- The two QAM carriers can be represented in a two-dimensional diagram → **constellation diagram**
- When using discrete and independent signals, each point in the constellation diagram can represent more then one bit



Constellation diagram

- Angle corresponds shift



QAM: placement of constellation points

- Signal is influenced by noise during transmission
  - Received signals are not at the ideal positions
  - Acceptance radius is required to define valid ranges for each point

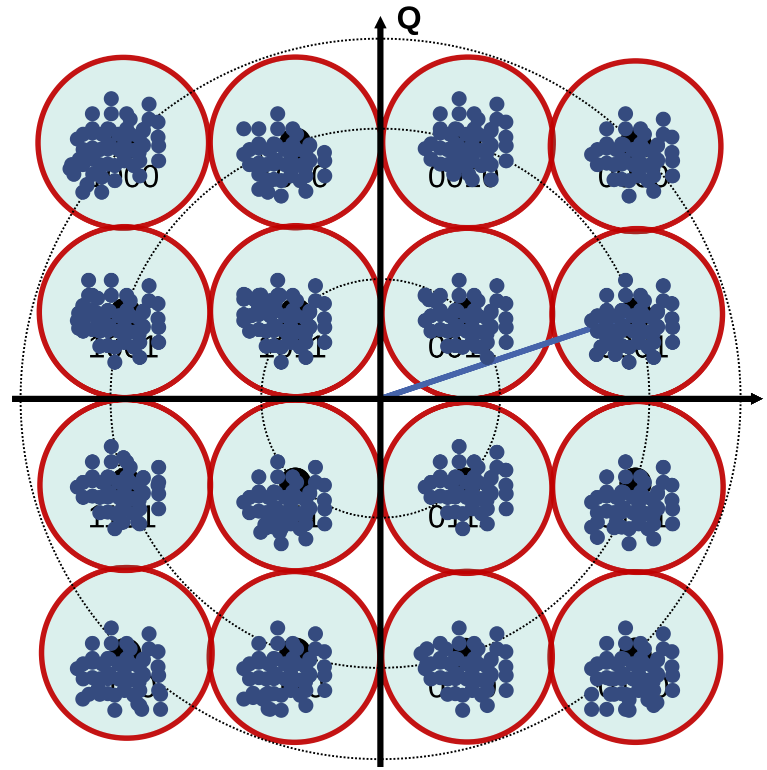
Positioning of signal points:

- Maximize distance of points to avoid misinterpretation of a signal

In General:

- More points allow more bits per signal (higher data rates) but require better signal-to-noise ratios

→ Trade-off required



Task 1:

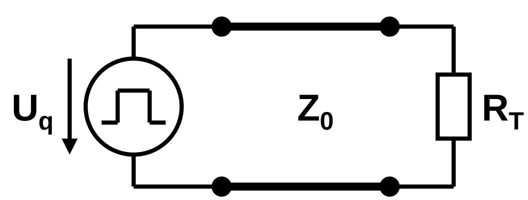
Quadrature Amplitude Modulation

Time allocated 10 min

Task 2:
Reflections on Wires

Reflection at the wire end

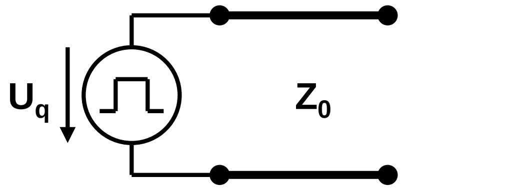
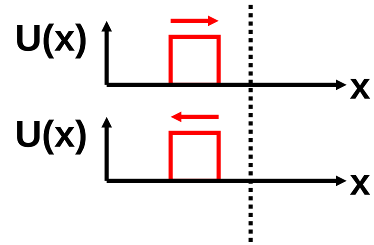
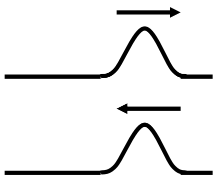
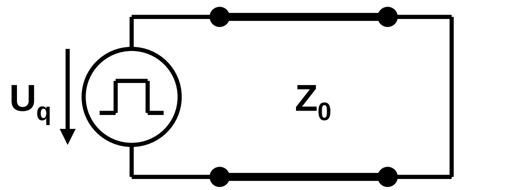
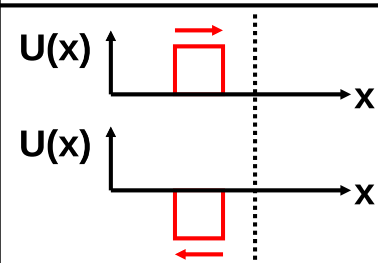
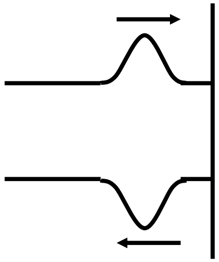
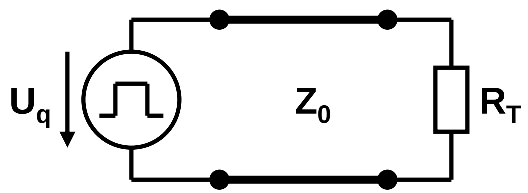
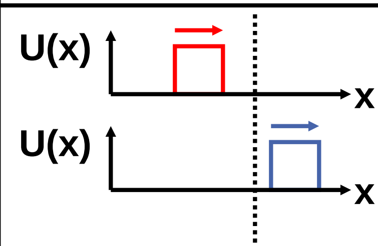
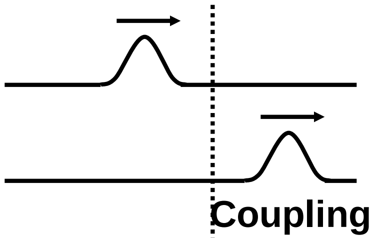
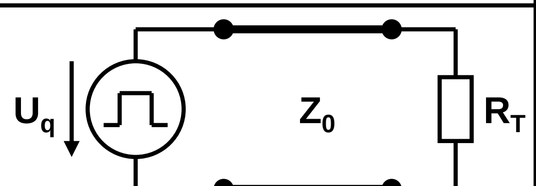
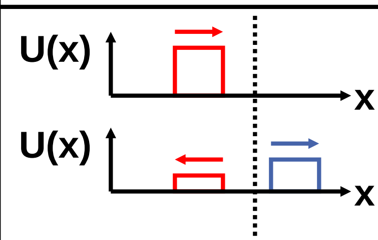
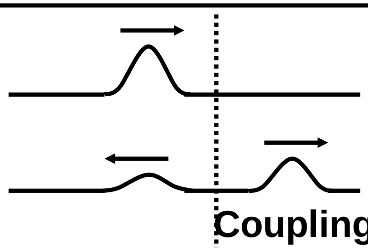
- Signals spread wavelike within long lines/wires
- There exists a forward and eventually a backward running wave that interfere on the wire
- The amplitude of the backward running wave depends on
  - The impedance of the line
  - The terminating impedance at the end of the line



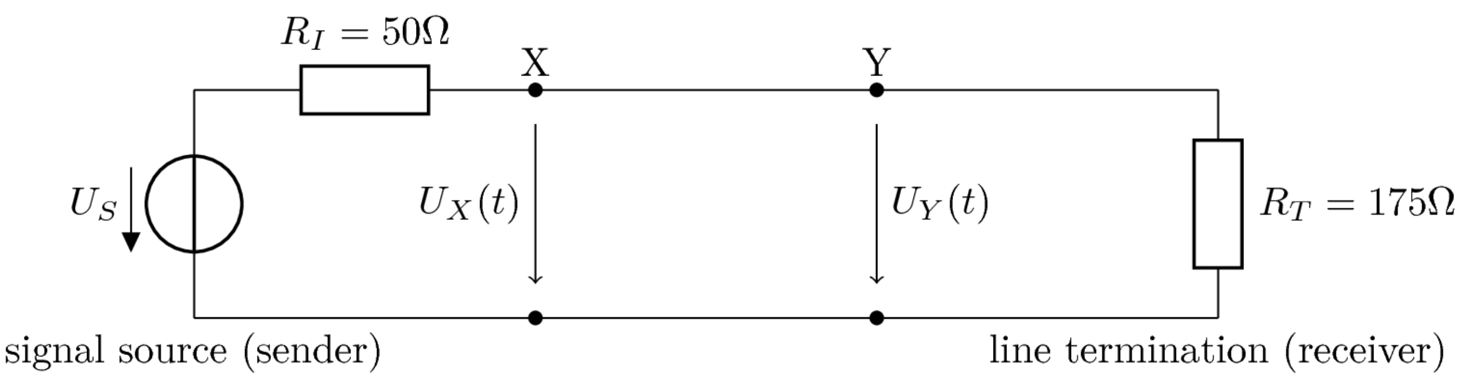
- Definition of the reflection factor: $r = \frac{R_T - Z_0}{R_T + Z_0}$

R_T: Terminal Resitance
Z_0: Characteristic impedance

Reflection on wires

Line	Reflection factor r	Voltage curve	mechanical analogue
 $R_T=\infty$	r=1		 loose end
 $R_T=0$	r=-1		 solid end
 $R_T=Z_0$	r=0		 Coupling joint
 $R_T \neq Z_0$	-1<r<1		 Coupling joint

Task 2: Reflection on Wires

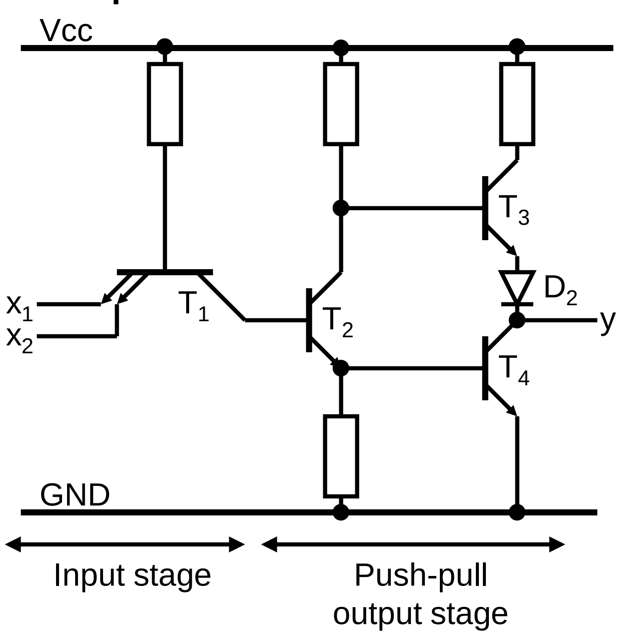


Time allocated **15 min**

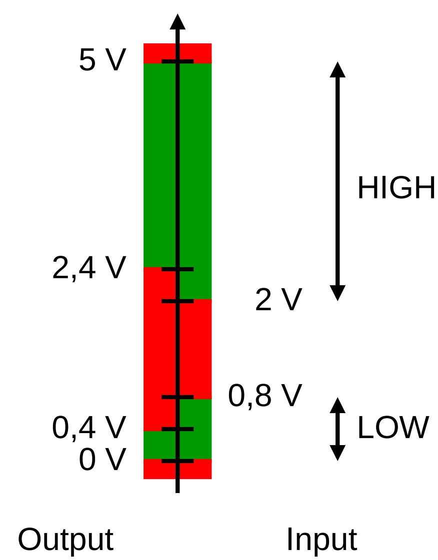
Task 3:
TTL Technology

Electrical Output Driver

- Transistor-Transistor-Logic (TTL)
  - In earlier times the most common used technology
  - Inverted Transistor 1 at input provides high input resistance
    → low load for previous circuit
  - Output transistors T3 and T4 are only conducting one at a time



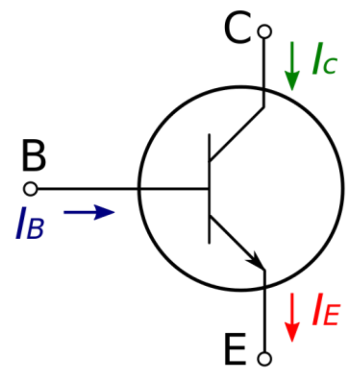
TTL basic gate (i.e. SN 7400)

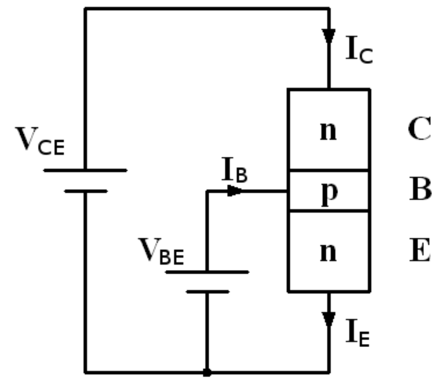


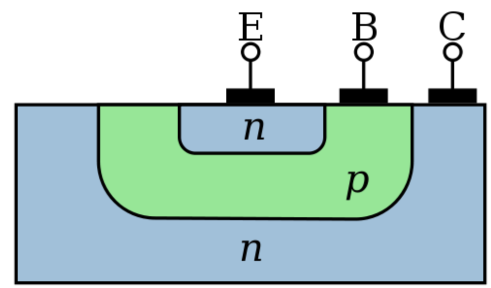
TTL levels

Bipolar junction transistor

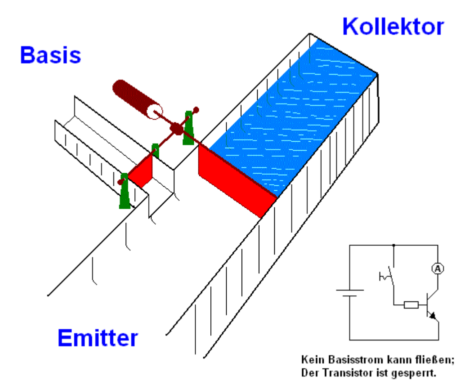
- NPN
  - layer of P-doped semiconductor (the "base") between two N-doped layers





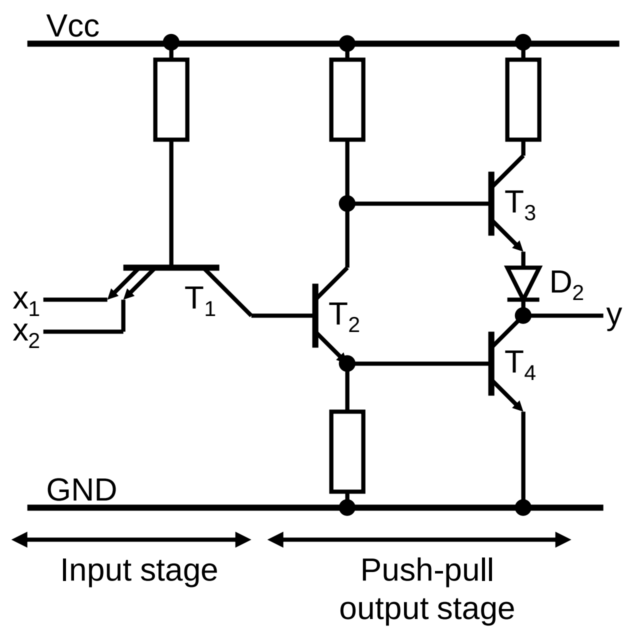


  - when there is a positive potential difference measured from the base of an NPN transistor to its emitter, the transistor becomes active



Source: https://en.wikipedia.org/wiki/Bipolar_junction_transistor#NPN

Task 3: TTL Technology



Time allocated

5 min