Tutorial 1 - SS2021
Communication Systems and Protocols

Institute for Information Processing Technologies - ITIV
Dr.-Ing. Jens Becker • M.Sc. Nidhi Anantharajaiah

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Task 1: Quadrature Amplitude Modulation

A) What is the difference between the PSK and the QAM modulation technique? 1

PSK modulates only the signal phase while QAM additionally modulates the amplitude of the signal.

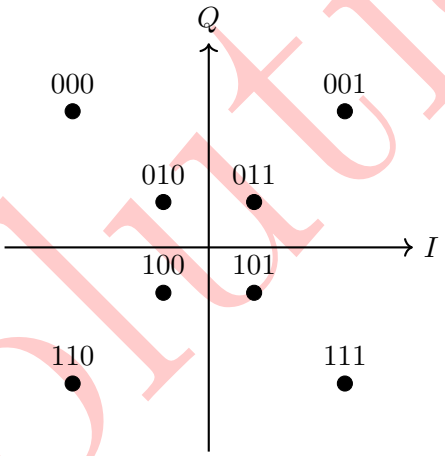

Figure 1.1: Constellation diagram

B) Figure 1.1 shows a constellation diagram for a digital modulation technique. Which type of modulation is used here? Which properties of the signal can be varied with this modulation type? 1

Modulation type: 8-QAM
Varied properties: Phase and Amplitude

C) The symbol constellation from Figure 1.1 is now used by a transmitter to modulate data bits on a carrier. The phase φ of the signal is defined relative to a sine reference signal as shown in Figure 1.2. A receiver device now picks up the modulated signal which is plotted in Figure 1.3. Which bits have been transmitted by the sender? Demodulate the signal and write down the resulting bit-stream.

3

Transmitted bits:
($\varphi = -\frac{\pi}{4}$, HIGH amplitude)111
($\varphi = -3\frac{\pi}{4}$, LOW amplitude)100
($\varphi = -\frac{\pi}{4}$, LOW amplitude)101
($\varphi = \frac{\pi}{4}$, HIGH amplitude)001

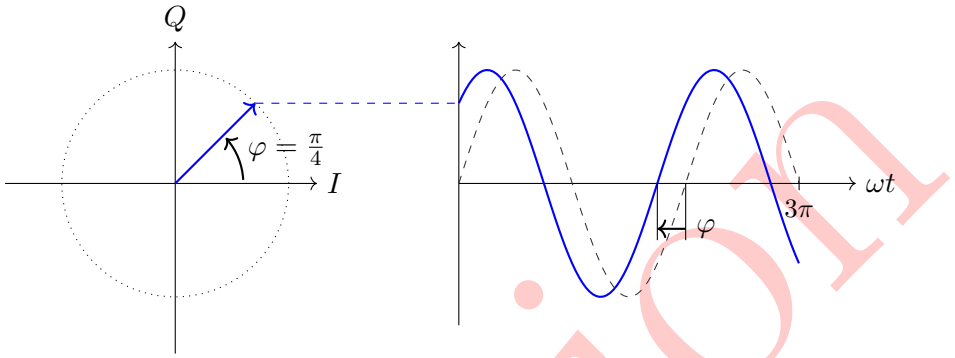

Figure 1.2: Phase difference of a sine signal compared to a reference signal (dashed line ≙ reference signal).

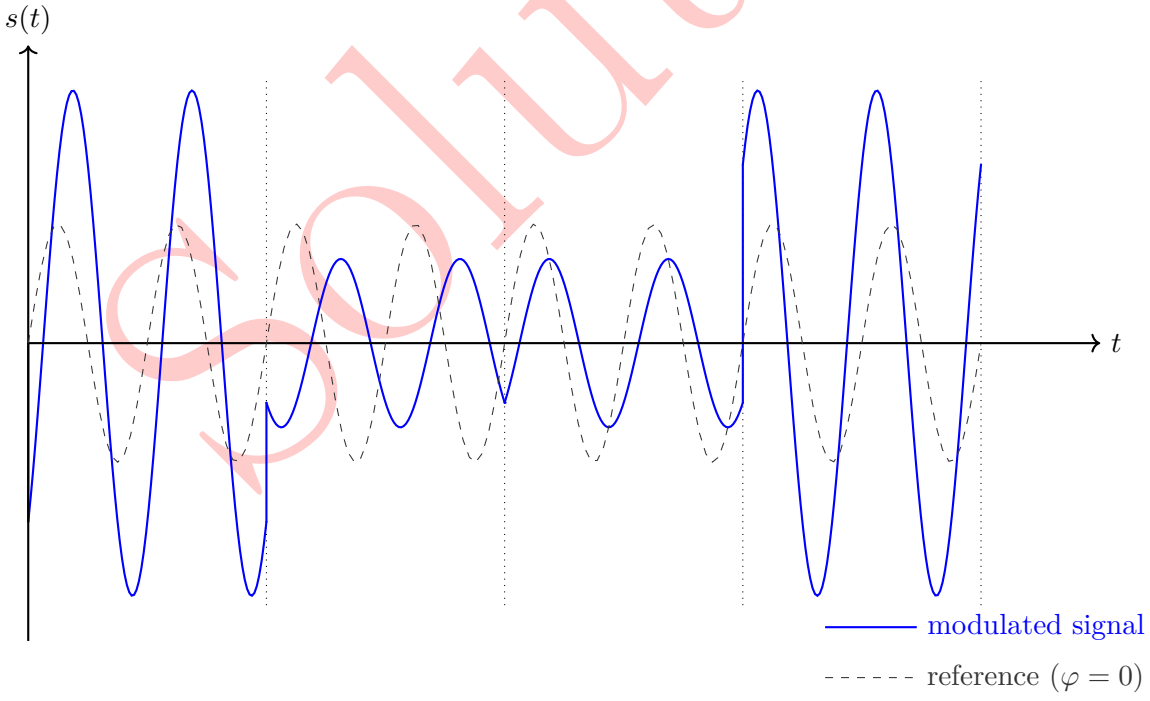

Figure 1.3: A modulated signal which uses the constellation from Figure 1.1 on the preceding page.

D) Now, a signal is modulated with the constellation diagram from Figure 1.4 and transmitted on a coaxial cable. The sender is able to generate a maximum voltage amplitude U_{max} of $\pm\sqrt{72}\,V$. Calculate the acceptance radius r_a for the symbols in the constellation diagram.

3

From the constellation diagram geometry: $(2 \cdot U_{max})^2 = (3\,(2r_a))^2 + (3\,(2r_a))^2$

$(2 \cdot U_{max})^2 = 72\,r_a^2$

$r_a^2 = \frac{(2U_{max})^2}{72}$

$r_a = \sqrt{\frac{(2U_{max})^2}{72}}$

Insert numbers: $r_a = \sqrt{\frac{4 \cdot 72}{72}}\,V \;=\; \sqrt{4}\,V \;=\; 2\,V$

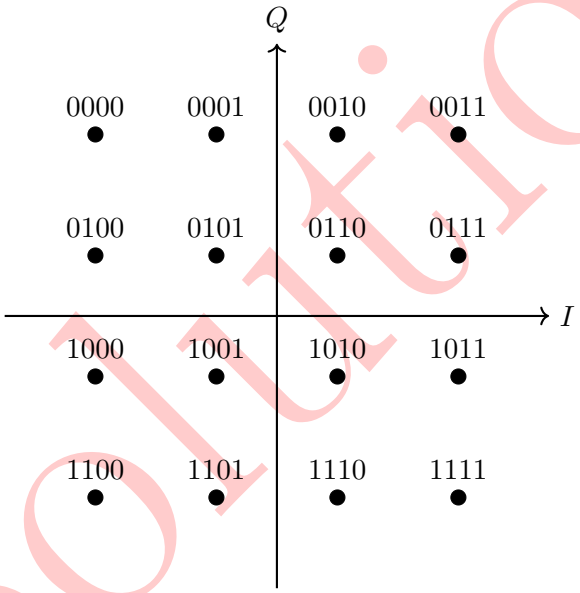

Figure 1.4: Constellation diagram

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Task 2: Reflection on wires

A setup consisting of a voltage source with an internal resistance $R_I = 50\Omega$ as sender and a receiver with $R_T = 175\Omega$ is shown in Figure 2. The DC resistance of the line is zero, the characteristic impedance Z_0 is 75Ω.

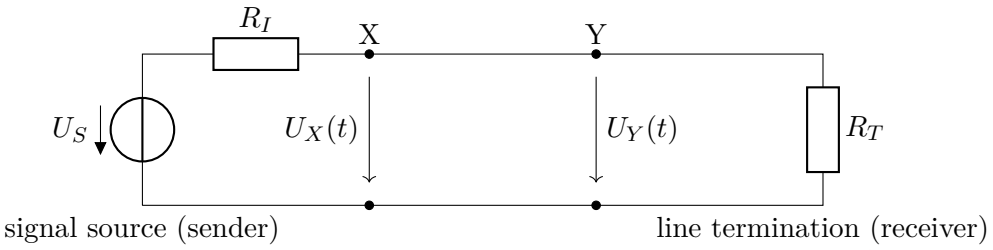

Figure 2.1: Test setup

At the time t= 0 the voltage U_s of the sender changes from $0V$ to $5V$ and is constant afterwards. The run time of a wave on the wire is t_d.

A) What is the value of the voltage at point X at the time $t = 0$? 1

At the time of $t = 0$ the wave only „sees“ a series connection of the internal resistance R_I and the wave impedance Zw.

$$U_X(0) = \frac{U_S}{R_I + Z_0} \cdot Z_0 = \frac{5V}{50\Omega + 75\Omega} \cdot 75\Omega = 3V$$

B) Which voltage value appears at the points X and Y after an infinite amount of time? 1

After an infinite amount of time the system is in a steady state, the voltages at points X and Y are identical. When neglecting the DC resistance of the wire a series connection of R_I and R_T remains.

$$U_X(\infty) = U_Y(\infty) = \frac{U_S}{R_I + R_T} \cdot R_T = \frac{5V}{50\Omega + 175\Omega} \cdot 175\Omega = 3.\overline{8}V$$

C) Calculate the voltages at the points X and Y at the times $t = 0 \ldots 5t_d$. Neglect all transient events, use ideal rectangular impulses for calculation. 4

Calculation of the reflection factors

- End of wire: $r_e = \frac{R_T - Z_0}{R_T + Z_0} = \frac{175\Omega - 75\Omega}{175\Omega + 75\Omega} = 0.4$
- Begin of wire: $r_b = \frac{R_I - Z_0}{R_I + Z_0} = \frac{50\Omega - 75\Omega}{50\Omega + 75\Omega} = -0.2$

In general:

- Voltage at point X for time t: $U_X(t) = U_Y(t-1) + r_b \cdot [U_Y(t-1) - U_X(t-2)]$
- Voltage at point Y for time t: $U_Y(t) = U_X(t-1) + r_e \cdot [U_X(t-1) - U_Y(t-2)]$

$\Rightarrow U_X(0) = 3V,\ U_Y(1) = 4.2V,\ U_X(2) = 3.96V,\ U_Y(3) = 3.864V,$
$U_X(4) = 3.8832V,\ U_Y(5) = 3.89088V$

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Task 3: TTL Technology

2

A) Insert the logic level (HIGH, LOW) of the output and the state of the transistors (conducts, blocks) into the table 3.1 according to the input configuration x_1 and x_2 at the standard TTL output driver in figure 3.1.

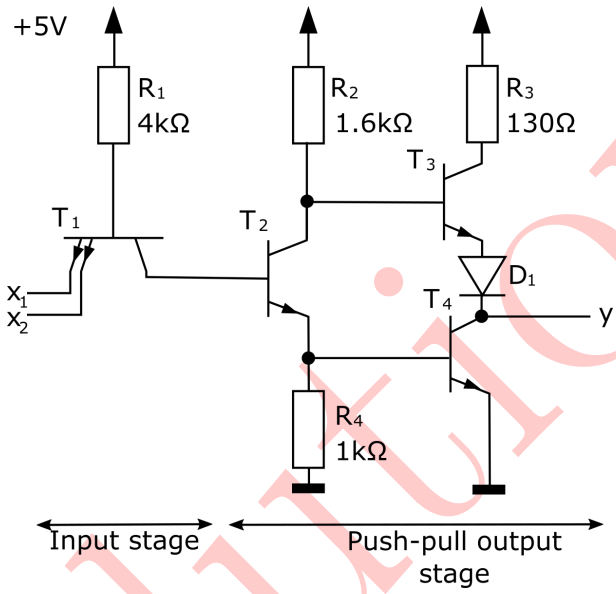

Figure 3.1: standard TTL output driver

x_1	x_2	T_1	T_2	T_3	T_4	y
Low	Low	ON	OFF	ON	OFF	H
Low	High	ON	OFF	ON	OFF	H
High	Low	ON	OFF	ON	OFF	H
High	High	OFF	ON	OFF	ON	L

Table 3.1: Logic Level

B) List two advantages when using TTL drivers.

1

High currents are possible;
Little energy is consumed while static