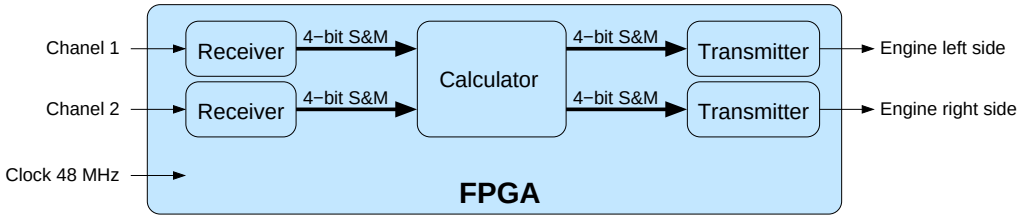
1 Prerequisites

Go to the directory of this week by executing the command:
cd ~/praktika/bte5024-digital/mini_project

2 Mini Project

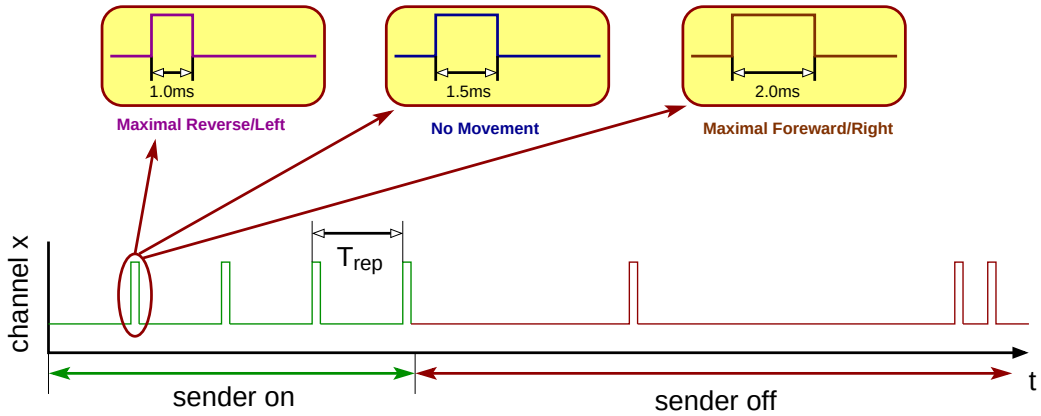
We are going to build the system as shown below:



This system has three basic building blocks. The functionality and requirements of these three blocks is described below.
Important: You are not allowed to use derived clocks, e.g. all flipflops are required to be clocked by the 48MHz clock.

2.1 The receiver

The robot contains a remote control receiver that generates a digital signal as shown below. The digital signal is entering the FPGA as *Channel x* and is a *Pulse Width Modulated (PWM)* signal.



If the remote control is switched on (*sender on*) the receiver receives a periodic signal with a period $\frac{1}{45}\text{s} \leq \text{T}_{\text{rep}} \leq \frac{1}{55}\text{s}$. If the remote control is switched off (*sender off*) the receiver receives random pulses that are non-periodic.
If the remote control is switched on, the width of the pulse indicates:

- No movement. If the width of the pulse is 1.5 ms the wheel and the trigger on the remote control are in the middle position.
- Maximum forwards/right. If the width of the pulse is 2.0 ms the wheel on the remote control is in its maximum clockwise position and the trigger is pulled in its maximum position.
- Maximum reverse/left. If the width of the pulse is 1.0 ms the wheel on the remote control is in its maximum counter clockwise position and the trigger is pushed in its maximum position.

Functionality: The receiver transforms the received digital signal into a 4-bit vector with Sign and Magnitude interpretation, where the sign bit indicates forwards/reverse, resp. left/right. The magnitude represents the speed. Furthermore, if the remote control is switched off the receiver should put the decimal value +0 on the 4-bit vector. A single bit signal indicates if the remote control is switched on (**1**) or off (**0**); this signal can be put on a LED of the robot. **Hint:** Think about *Meta-stability*!

2.2 The transmitter

The transmitter generates a PWM signal equal to that of the remote control when it is switched on (see above). The period of this signal $T_{rep} = \frac{1}{50}$s.
Functionality: The transmitter receives a 4-bit vector with Sign and Magnitude interpretation, where the sign bit represents forwards/reverse, resp. left/right and the magnitude represents the speed. The receiver transforms this S&M value into the described PWM signal. **Hint:** Think about *Hazards*!

2.3 The calculator

The calculator receives the two 4-bit vectors indicating forward/reverse and left/right movements. The calculator transforms this information into two 4-bit vectors that go to the left and right engine. The calculation that has to be performed is that:

- If there is no left/right movement both engines need to go with equal speed forwards/reverse indicated by the 4-bit vector coming from the forward/reverse receiver.
- If there is left movement the left engine needs to go the amount indicated by the left movement slower than the right engine.

- If there is right movement the right engine needs to go the amount indicated by the right movement slower than the left engine.

Requirements: Only for this block you are required to generate a test-bench.
Hint: Think about *overflow* and *underflow*!

3 FPGA pins

The table below describes all the pins on which the leds/clock/engines/channels are connected, you can use it in the `project.ucf` file.

Component	FPGA Pin	Component	FPGA Pin
Channel 1	N5	Channel 2	M8
Channel 3	M7	Left engine	R14
Right engine	T14	Clock	N9
LED 0	P13	LED 1	P12
LED 2	N11	LED 3	P11
LED 4	P10	LED 5	P9
LED 6	P8	LED 7	P7
LED 8	P6	LED 9	N6
LED 10	P5	LED 11	T2
LED 12	T3	LED 13	R3
LED 14	T4	LED 15	T5
LED 16	R5	LED 17	T6
LED 18	T7	LED 19	R7

4 Grading :

Each group has on the last lecture of this semester 10 minutes to demonstrate their results. The grades are given as:

- **Receiver:** Only a working simulation in Modelsim: $\frac{1}{2}$ point.
  Demonstration of correct functionality on the robot: 1 point.
- **Transmitter:** Only a working simulation in Modelsim: $\frac{1}{2}$ point.
  Demonstration of correct functionality on the robot: 1 point.
- **Calculator:** Only a working simulation in Modelsim: $\frac{1}{2}$ point.
  Also having a C-model: $\frac{1}{2}$ point.
  Also having a test-bench: $\frac{1}{2}$ point.

Complete calculator with demonstration: 2 points.
E.g. this module gives a maximum of 2 points.

- **Complete System:** Working complete system on robot: 1 point.

If the system is not implemented using the Sign and Magnitude interpretation each of the above items is punished by $-\frac{1}{4}$ point.
Maximum points: 5.