Toward 100-Gbit/s 240-GHz short-range communication using SiGe-transceivers and an FPGA-based baseband

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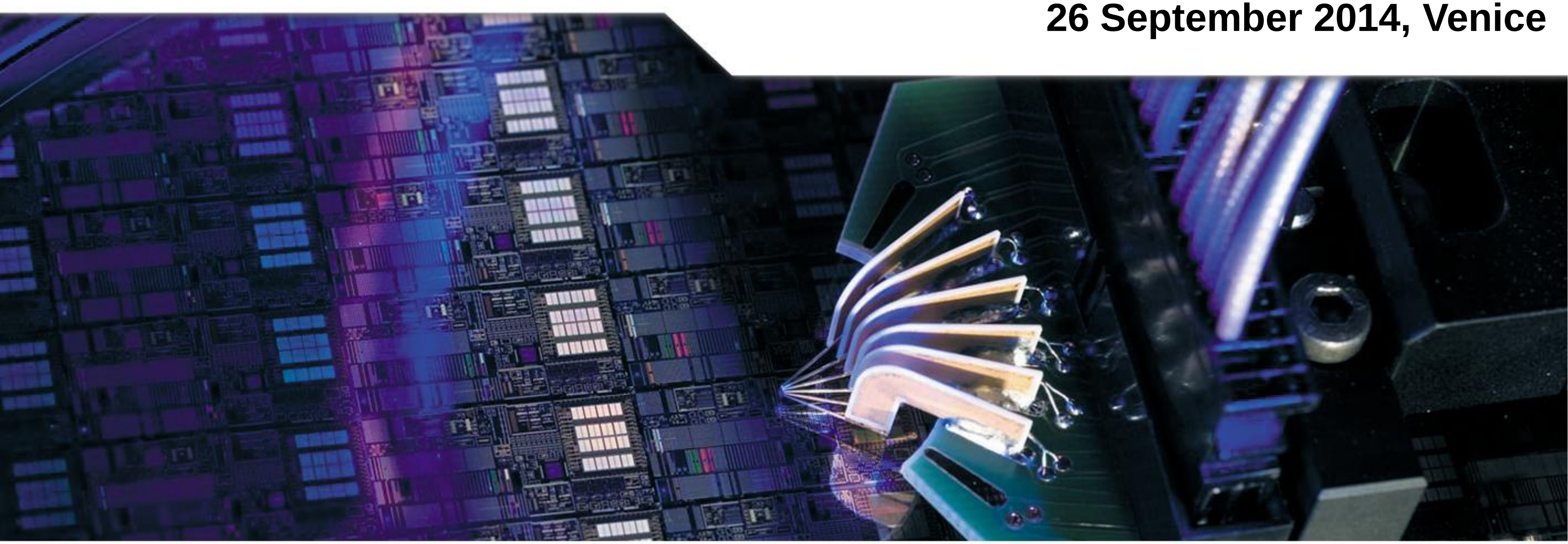

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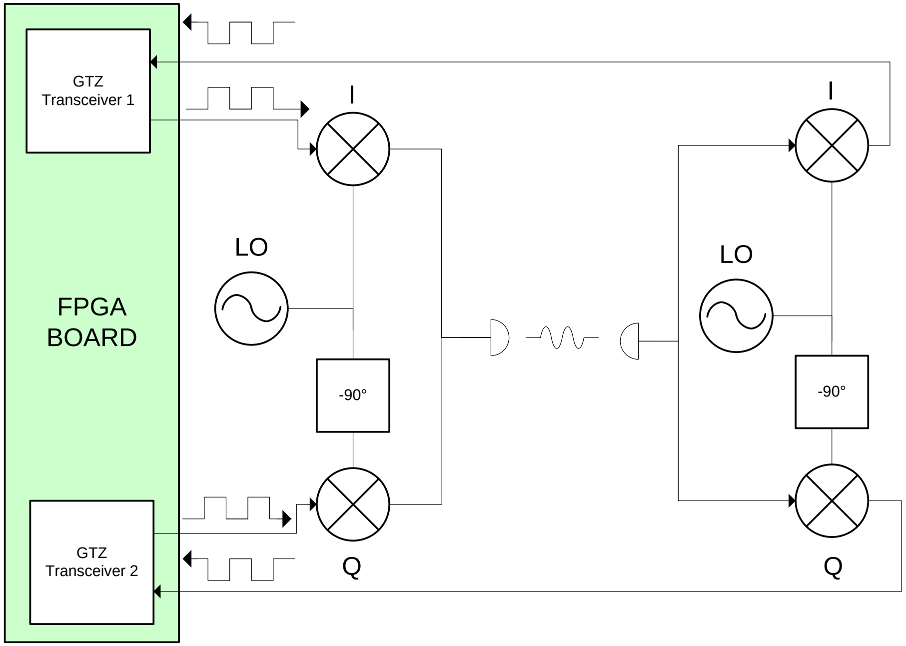
56 Gbps Short Range Communication with FPGA and SiGe-transceivers

- Xilinx Virtex 7 FPGA has high speed transceivers that are capable of generating baseband signals with bitrates up to 28 Gbps
- Use QPSK with IQ-mixer to double the bitrate to 56 Gbps with the same bandwidth.



Challenges and Obstacles

- A baseband signal with a bit rate of 28 Gbps requires a 40 GHz+ bandwidth channel, and hence the signal will occupy the entire spectrum from DC to 40 GHz.
  - The insertion loss as a function of frequency will have a very steep roll-off, and the channel basically becomes a low-pass filter resulting in lower SNR and Intersymbol-interference (ISI)
  - Dispersion/group delay variation results in ISI.
  - Timing Jitter of the transmitter clock signal and the recovered clock at the receiver result in timing errors.

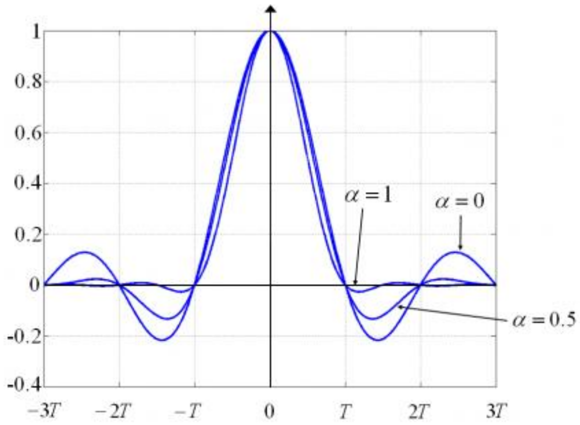
Challenges and Obstacles (contd.)

- The RF-channel at 240 GHz can present the same problem with narrow bandwidth and dispersion.
- An issue related to the jitter in baseband channel, will be carrier phase noise and syncronization of the receiver LO with the received signal.

- All these factors from both channels contribute to the signal quality. To succes with the task of succesfully transmitting a 56 Gbps signal over a 240 GHz wireless channel with a low Bit-error rate (BER) these will have to be compensated for.

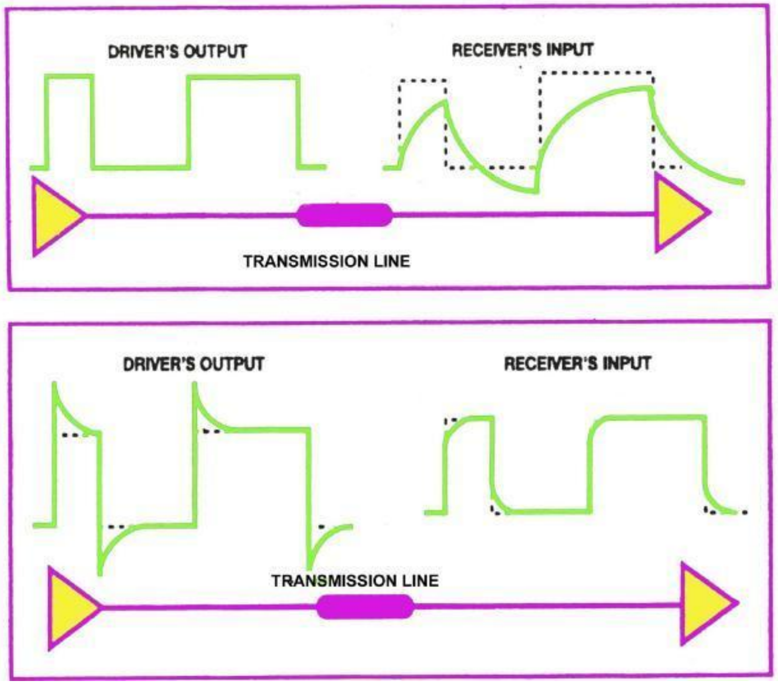
Pulse shaping

- Pulse shaping of the "square" waves can be performed to lower it's high frequency content and thus make it better suited for the characteristics of the channel.
- Can be done digitally with the FPGA, but also possible to implement analog filters. E.g. raised cosine or gaussian pulse.



Pre-emphasis

- Pre-emphasis of the transmitted signal will be used to to flatten the steep roll-of the channel response.

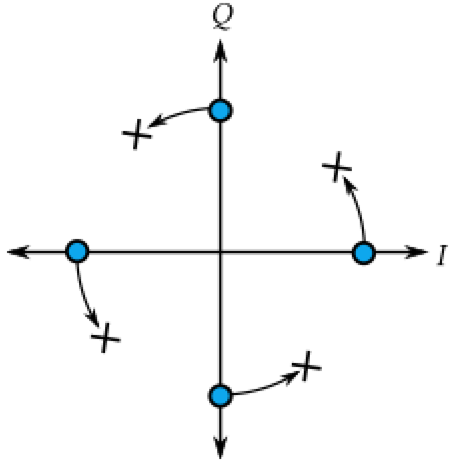


Equalization

- Equalization to compensate for channels low pass response and dispersion.
- Either measure eye quality and choose filter coefficients for optimal eye opening.
- Or for a fixed setup, measure the channel with a vector network analyzer and choose the taps that best compensate for the channel (dispersion and attenuation).

Phase Coherency between TX and RX

- Phase syncronization of the transmitted signal and receiver LO is of vital importance in IQ-modulation. A phase error will rotate the constellation diagram as shown in the figure below.
- Usyally done with a carrier recovery, e.g. a costas loop to extract the phase of the received signal.
- We start with using a manual phase shifter on the receiver LO to get phase coherency.

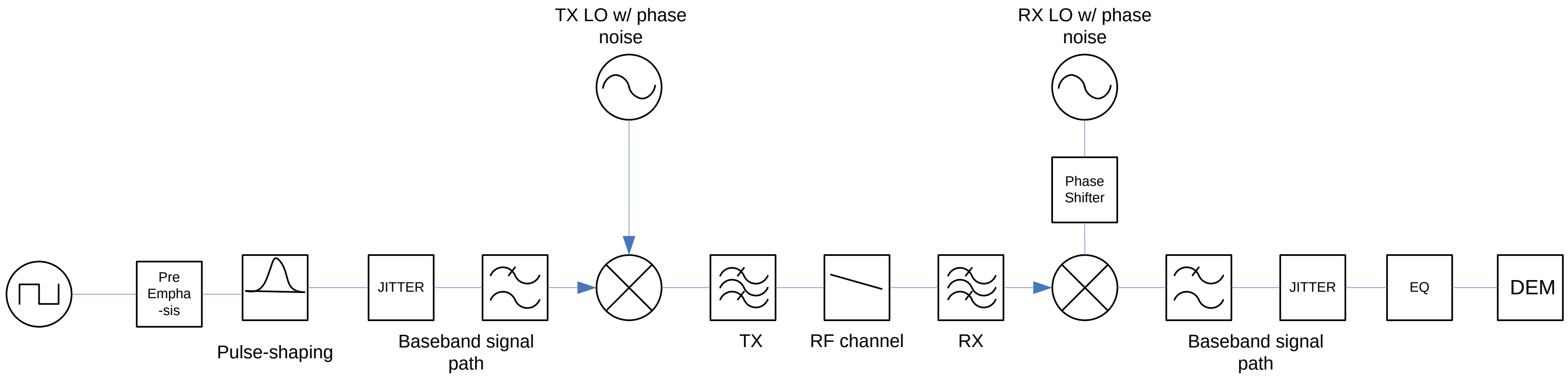


Coding

- 8B/10B coding for DC-balance to avoid charge build-up in the channel
- Forward-correction (FEC) might be considered if needed

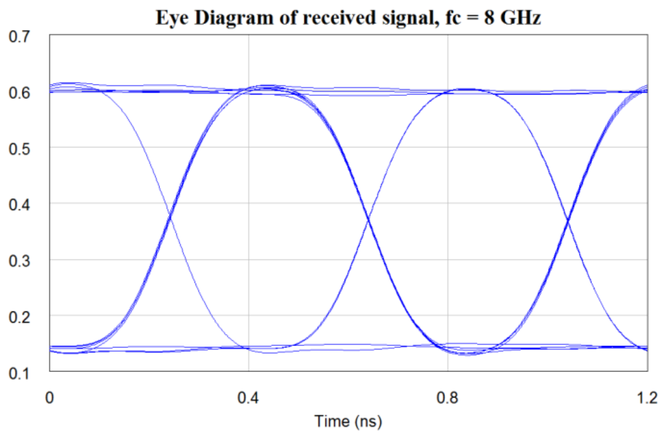
System Block Diagram

- Block diagram from FPGA Transmitter to FPGA Receiver

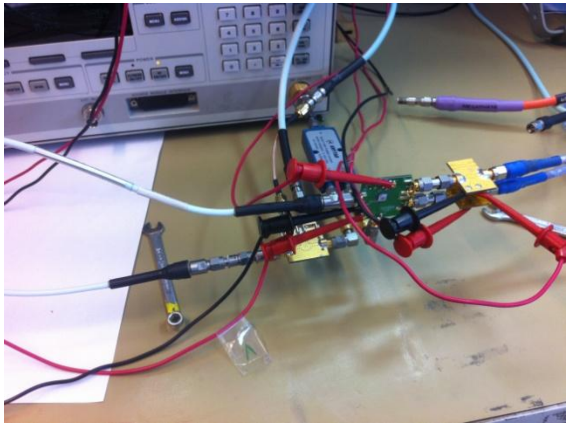


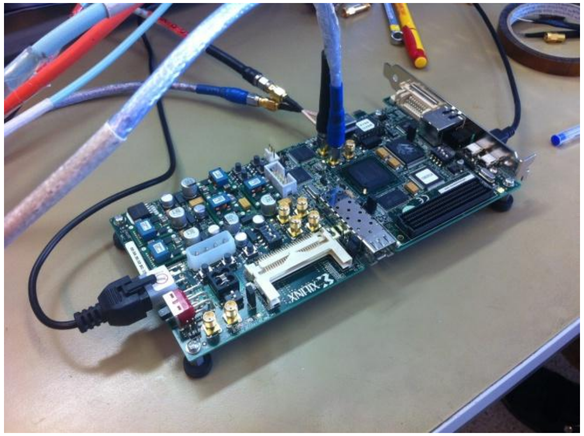
Performed Test of the Concept at Lower Frequencies

- 5 Gbps QPSK signal over an coaxial cable channel with a Xilinx Spartan 6 FPGA-board and IQ-mixer at Fc = 8 GHz
  - Error-free communication was carried out.
  - Pulse-shaping, pre-emphasis or linear equalization had very little effect on the perfomance. This is to be expected due to the bandwidth (~ 2 GHz) of the channel which acts as a pulse shaping filter and eliminates the problems with ISI and dispersion.



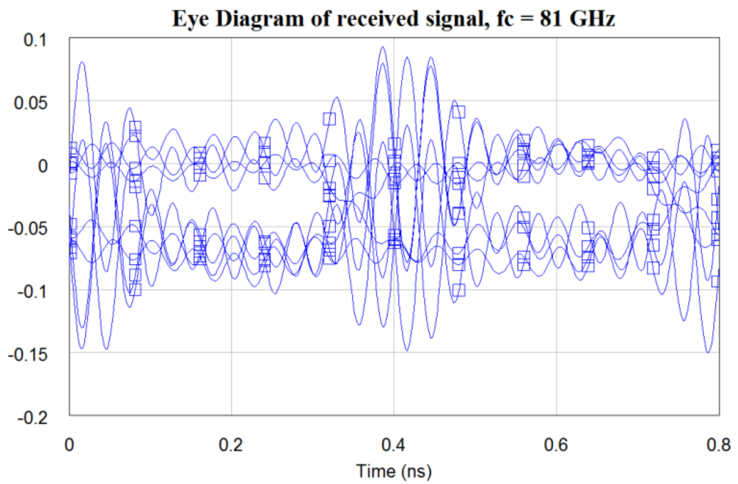
Measured channel with simulated PRBS-signal



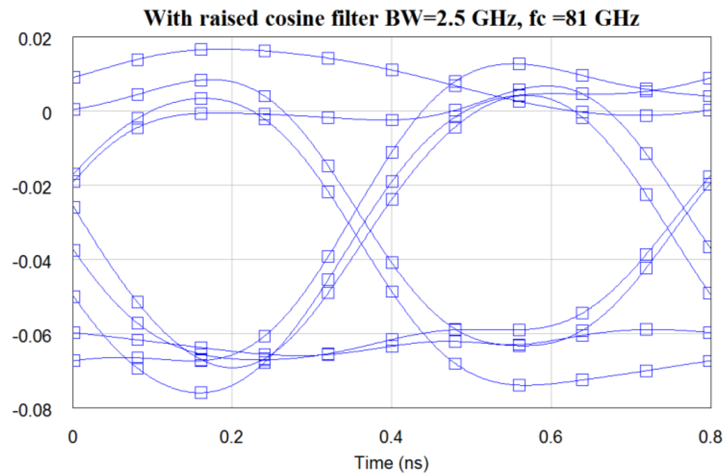


Performed Test of the Concept at Lower Frequencies (contd.)

- Same baseband unit but with an IQ-Mixer at Fc = 81 GHz (E-band) and a waveguide channel.
  - Error-free cmmunication was not possible. Over the wide bandwidth (10 GHz), the group delay variation becomes too large, and it was not even possible to compensate it enough with pre-emphasis or linear equalization. Pulse shaping and/or more advanced equalization alghoritms are needed.



Measured channel with simulated PRBS-signal



Measured channel with simulated PRBS-signal and simulated pulse-shaping filter

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