Radar Module

Degree programme: BSc in Electrical Engineering and Information Technology | Specialisation: Embedded Systems
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Expert: Daniel Kühni
Industrial partner: HaslerRail AG, Bern

Radar sensors enable contact-free and accurate measurement of speed and distance and are a valuable part of HaslerRail's product portfolio. Furthermore, costs are an important factor for the competitiveness of a product. Therefore, the development of a low-cost radar opens up many possibilities for radar-based applications with lower performance requirements. With this aim, a low-cost radar module for speed measurement was developed.

Context and Goals

HaslerRail's product portfolio consist of electronic safety components for the railway industry including a Doppler radar module, which features a highly flexible and performant Zynq-SoC processor. The aim of the project was to develop a low-cost radar prototype based on a less expensive Hercules safety microcontroller of Texas Instruments. In the preliminary phase of the project the existing radar module was redesigned and externally produced. The goal of the current work was to test the hardware and to design and implement the firmware.

Concept and Implementation

The radar module is operated in continuous wave mode, in which a constant, continuous wave is transmitted by the radar. If the wave is reflected by an object with a radial, non-zero speed, the wave is changed by the Doppler Effect. This effect is exploited to detect speed and direction of movement of the reflector.

The radar module consists of a radar chip with on-chip transmit/receive antennas. The radar chip amplifies the received signal and shifts it to baseband by the integrated quadrature mixer. The resulting IF_I and IF_Q signals are then amplified and low pass filtered before being sampled by the analog to digital converter (ADC) of the microcontroller. The ADC data is stored in a dual buffer system to enable simultaneous sampling and processing of the data. A Fast Fourier Transformation (FFT) is performed followed by detecting the frequency bin with the maximal magnitude peak. The resulting frequency is used to calculate the speed according to the Doppler formula.

Results

The existing radar module of HaslerRail was redesigned, externally produced and successfully tested. The firmware was designed to generate low CPU load by the data sampling and use direct memory access to transfer the sampling data from the ADC result memory to a dual buffer system. This allows concurrent data sampling and processing. Data processing was implemented using an efficient way of calculating the FFT of two real-valued data buffers and a fast algorithm for the calculation of the magnitude-spectrum. First tests of the radar module were successfully performed.

Conclusion and Future Work

Based on the hardware of the existing radar module, a low-cost radar module was developed. First test results indicate that the Hercules microcontroller is well suited for use in the radar module. Future work includes more in-depth testing of the firmware, to confirm the suitability of the microcontroller. Furthermore, the implementation of the frequency modulated continuous wave mode would enable the measurement of distance. This would pave the way towards the development of additional radar applications.

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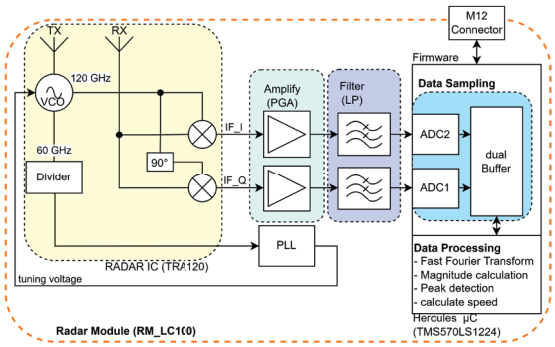
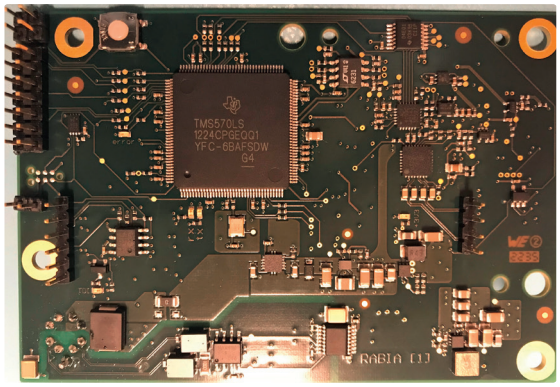


Block Diagram - Radar Module



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