TACT as a Learning Tool for Radio Design

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Abstract

TACT is an EDA tool that can be very valuable in an educational context since it can help students in electronics and communications acquiring skills that will be fundamental for their careers. TACT is suite of tools the purpose of which is to explore the design space of multi-standard radio transceivers. The use of this tool can ease and speed up the learning process related to the system level design of chipsets suitable for communication applications. The outputs from TACT can easily be combined with available commercial tools in order to provide a complete design flow from system to silicon. This paper highlights the main features that make of TACT a very useful tool in education.

1. Introduction

The increasing complexity of communication systems together with the demands for short time-to-market puts a lot of pressure on the system engineers. Efficiently evaluating and comparing the feasibility and performance of different receiver implementations at an early design stage, i.e. system level, is key to succeed in surmounting this engineering challenge. A deep understanding of the trade-offs that govern the performance of communication receivers is capital for RF system engineers. This understanding is, therefore, a skill engineering students in related areas should carry along when they say goodbye to their university days.

The traditional approach when designing and teaching receiver analysis and design often relies on hand calculations or Excel sheets. Using these methods can help at the beginning of the learning process. Nevertheless, this approach is generally cumbersome, not very flexible, and in many instances, error prone. Electronic Design Automation (EDA) tools can help speeding up the process of providing students with the necessary insight.

This paper discusses the applications in education of a Multi-standard RF Transceiver Architecture Comparison Tool (TACT) [1], developed at the Royal Institute of Technology (KTH), Stockholm, Sweden. TACT can be used independently or together with other available tools in an integrated design flow. Its applications are not limited to education, TACT can also be used for high level receiver design both for industrial and research purposes.

2. TACT Overview

TACT, whose Graphical User Interface (GUI) is shown in Figure 1, is a modular, user friendly, MATLAB based tool. It automates the design space exploration procedure for communication receivers with a focus on 4G wireless receivers. The tool partitioning into its different components and simulation flow is given in [1]. A thorough description of the underlying methodology and algorithms TACT is built upon is given in [2], [3]. TACT proposes an interference oriented approach when evaluating the performance of each possible frequency in order to find the most suitable frequency plan. As far as budget design is concerned, TACT's objective is finding a multi-standard receiver budget that meets or exceeds the specs of the addressed wireless standards while keeping the requirements of each of the receiver blocks as relaxed as possible. TACT is not meant to substitute already available tools such as ADS [4] or Cadence [5], but to complement them.

3. Integrated Design Flow

The design flow goes from system level specifications to silicon implementation using TACT, ADS and Cadence tools as it is shown in Figure 2. In order to ease the tool integration, an interface with ADS is under development. Figure 3 shows the view corresponding to a zero-IF receiver. TACT's GUI provides the option of storing the simulation results. These data can then be read by ADS. The value for each parameter generated by TACT can be then assigned to the block it belongs to in ADS.
In ADS the large signal, non-linear simulations are carried out using harmonic balance. The analysis in the small signal, linear region is performed by means of an AC simulation.

4. TACT: The Education Perspective

TACT can help students understand the trade-offs to consider when designing a communications receiver. A deeper understanding of the design parameter interdependencies can be achieved just by "playing" with the tool. Only with a mouse click the effect of changes in the various parameters that determine the receiver performance can be visualized in TACT. TACT's Graphical User Interface (GUI), shown in Figure 1 makes it a very intuitive and easy to use tool. TACT's GUI helps visualizing:

- The impact of the frequency plan in the performance of the receiver with respect to interferers.
- The impact a change in the characteristics of a block has on the overall performance of the receiver in terms of gain, noise performance, etc.
- The receiver characteristics different standards lead to.
- The degree of hardware sharing that can be achieved in a multi-standard receiver.

This tool is going to be used in the course 2B1670 Advanced Topics in Mixed Mode Design at the Royal Institute of Technology (KTH) in Stockholm, Sweden from the fall term 2007. This course belongs to the System-on-Chip Design Master Program offered at KTH. The objective of this course is to provide understanding and experience with the design of mixed-signal integrated circuits (ICs) from system concept to fabrication level. Focusing on RF applications, the design of a wireless receiver will be used as an example. TACT will be used to define the system specifications, ADS to perform the system level simulations, and Cadence's Virtuoso family of tools for the transistor level simulations and layout.

As was mentioned before, students can easily become familiar with the "tricks of the trade" of designing the system level specifications of communications receivers thanks to TACT [6]. They can, for instance, see how neighboring intermediate frequencies can have very different performance in terms of intermodulation performance. Once they have chosen an appropriate frequency plan, they can explore the effects of choosing different receiver architectures or block sequences with just a few clicks. They can even fix manually the characteristics of a block and see how it affects the settings of the rest of the receiver. Once these possibilities have been explored it is easy to transfer the results to ADS and continue to a lower level in the design flow until the post-layout simulations can be performed in Cadence and the circuit can be sent for fabrication.

5. Conclusions

This paper shows how a Multi-standard RF Transceiver Architecture Comparison Tool, TACT, can be used for educational purposes. TACT can walk students through the intricacies of communication receivers design. This tool can be used as an educational support in university courses as well as in a self-study fashion and can be combined with existing commercial EDA tools in order to provide a complete design flow.

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References