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Application of EDA Technology in Intelligent Communication Electronic Circuit

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Abstract: Electronic design automation (EDA) technology is the product of the computer age and finds its foundation in CAD, CAM, CAT, and CAE. EDA is a kind of auxiliary tool in the design process, which requires the designer to carry out the file design work using hardware language as the foundation. Subsequently, the computer system automatically compiles and integrates the file to achieve simulation goals, and can complete the programming download of the target chip. At present, this technology is widely used in the communication of electronic circuits. This paper summarizes EDA technology and analyzes its specific application in communication electronic circuits, aiming at promoting the application of CDA technology and promoting the further development of the communication field.

Keywords: EDA technology; Intelligent communication; Electronic circuit

1. Introduction

In the 21st century, human beings have entered the computer age, and the development of any field is inseparable from computer technology, among which electronic design automation (EDA) technology is a typical representative of advanced computer technology, which is mainly used in the design of communication electronic circuits. The communication industry is the fundamental element of social and economic development, and the stability of communication electronic circuits will have an important impact on the development of other fields, so it is necessary to conduct in-depth research on the application of EDA technology in communication electronic circuits.

2. EDA technology overview

EDA technology operates on computer platforms and continually evolves in tandem with advancements in computer technology. Its most distinctive feature lies in the design process, which contrasts with the traditional electronic design process. EDA employs a top-down approach, commencing with the overarching concept, planning the interrelations among various components, rectifying design errors through simulation, and ultimately reducing the error rate. When describing high-level language logic, EDA serves as a critical support, allowing designers to delineate the hardware functionalities of the system according to their design needs, thereby facilitating electronic circuit design. In summary, the application of this technology in electronic circuit design enhances design efficiency, mitigates the occurrence of design errors, and plays a pivotal role in the development of the communication field [1].

3. The specific application of EDA technology in communication electronic circuits

3.1. Application to radio frequency electronic circuit design

The design of a radio frequency (RF) electronic circuit requires the support of EDA technology, with a toolkit that comprises three types of software: programmable chip design software, chip-assisted design software, and system design software. These software tools collectively enable the preparation of the design files with the use of very high-speed integrated circuit hardware description language (VHDL), which is a hardware description language. Upon the completion of logical compilation tasks, the system automatically segments and simplifies the compilation outcomes. Subsequently, several key tasks are essential for the target chip: firstly the accomplishment of logic mapping; secondly, the execution of adaptation compilation; and thirdly, the successful programming download.

EDA technology also contains two types of important software packages: the synthesizer and the adapter, which the latter needs the support of the former to form a file configuration. These files are placed in the target device after the generation of downloaded files such as JED. When selecting the target device, the adaptability of the adapter as well as the relationship between the adapter and the synthesizer need to be considered. The synthesizer must first comprehend the hardware structure parameters, convert the high-level language in the circuit into a low-level description, and then carry out a series of compilation and conversion works before it starts working [2].

When this technology is applied to RF electronic design, each unit circuit and the total circuit need to be simulated and verified, which requires the electronic simulation component model to provide support. Under normal circumstances, these component models have typical characteristics, the component parameters show obvious discreteness, and the distribution of all electronic circuits needs to follow certain laws. To begin with, the schematic circuit is designed using tools such as Menter and Protel, and the design file can be generated. The circuit performance of the design also requires testing. Simulation software is used for detecting the wrong connection modes in the circuit and giving reminder contents that the designer can modify accordingly and generate a correct and perfect design drawing. The printed circuit board (PCB) is then generated according to the design. It is worth noting that EDA technology has higher requirements for PCB size and large device density, and must be routed following the prescribed rules. PCB design poses a greater level of complexity, but with the assistance of these auxiliary software tools, it becomes possible to streamline the design process, effectively manage circuit signals, and ultimately generate a comprehensive PCB layout. This finalized layout serves as the foundation for production in the factory.

3.2. Applications in radio frequency electronic circuit design

EDA technology leverages computers as tools, empowering designers to utilize the EDA software platform alongside the hardware description language VHDL for the creation of design files. Thereafter, the computer automatically undertakes tasks encompassing logic compilation, simplification, segmentation, synthesis, optimization, layout, wiring, and simulation. This comprehensive process leads to the eventual adaptation compilation, logic mapping, and programming download for the specific target chip.

In terms of its development trajectory, EDA technology has experienced three distinct stages. The initial stage involved EDA's application in electronic circuit CAD, employing simulation software like Eesolf and Protel, which served as essential tools for domestic circuit design developers over many years [3]. During this stage, the primary objective was to harness the computer's program editing capabilities to formulate circuit theoretical algorithms and related empirical formulas, gradually transitioning toward more sophisticated functions such as auxiliary analysis and PCB production. While the early adoption of EDA software alleviated the labor burden and enhanced efficiency, it was characterized by relatively low levels of intelligence due to its nascent stage.

The second stage of EDA development witnessed the introduction of automatic layout and circuit-level simulation and analysis capabilities, driven by competition among EDA companies in developed nations. During this stage, EDA technology demonstrated improved intelligence. Since then, EDA technology continued to evolve, reaching its pinnacle in the late 1990s when it transitioned from a rudimentary software with limited functionality to a sophisticated simulation system capable of replacing much of the manual effort. In the mature stage, EDA technology proved exceptionally valuable, particularly in the realm of radio frequency electronic circuit design.

Currently, the most widely employed EDA software in the field of RF technology includes Agilent's ADS software, Ansoft's HFSS designer software, and CST software. In addition, circuit design software like AWR and Serenade are also widely used. Among China's universities and numerous research institutes, ADS software stands out as the most extensively utilized, as it is a comprehensive electronic design software offering capabilities for circuit design analysis, device analysis, electromagnetic (EM) compatibility analysis, and more. On the other hand, HFSS software excels in solving enclosed domain problems and conducting radiator calculations. AWR or Serenade software shines in swiftly calculating parameters. For designing microwave components like filters, the filter design guide software comes into play. The initial design can be created using this software, followed by constructing a model through ADS EM simulation or HFSS software. Subsequently, the simulation design can be optimized using the method of moments (MOM) or finite element method (FEM), significantly enhancing design efficiency and accuracy.

For instance, the microstrip filter is designed using AWR and ADS software, and its technical specifications call for a frequency range of 4.25–5.55 GHz with a band interpolation loss of 1 dB. The design process begins with the AWR software's filter synthesis wizard, which facilitates rapid filter fitting calculations. In this case, a 5th-order half-wavelength wide-side coupled resonant microstrip filter is selected as the design task [4]. Parameters like band interpolation loss (set to 0.2 dB), bandwidth (chosen as 3.85–5.95 GHz), and dielectric substrate properties ($\varepsilon = 9.6$, 25 mil thickness) are configured. These settings yield a calculation model for a 5-order half-wavelength wide-edge thickened microstrip filter. After adding excitation, S-parameter curves are obtained. To enhance the accuracy of the design results and account for transmission line discontinuities and edge capacitance, electromagnetic values need to be calculated. Here, the powerful capabilities of ADS software come to the forefront, where the process begins with correcting each transmission coupling line segment involved in the filter, followed by moment method analysis in the EM mode. The moment method accurately simulates and optimizes the filter within the semi-open domain of planar circuits.

The calculated microstrip line impedance and corrected sizes of each segment are embedded within ADS. The model is then established in EM simulation mode. Ultimately, the sub-bandpass filter's 3 dB bandwidth, simulated using ADS software, falls within the range of 4.05–5.98 GHz, with a band interpolation loss below 0.36 dB, meeting the relevant requirements. However, when an actual filter is fabricated and tested, the 3 dB bandwidth is measured as 4.41–5.39 GHz, with a somewhat deteriorated band interpolation loss. This degradation can be attributed to inherent losses in the microstrip line and incomplete port connections.

Nevertheless, the passband center remains generally stable.

3.3. Application to the frequency divider design

Frequency dividers constitute a fundamental component of electronic circuits, and their selection varies based on different communication electronics. When designing these circuits, there are generally two options for frequency division: half-integer frequency division or integer digital frequency division. In some cases, multiple electronic circuits may necessitate various forms of frequency division. The choice depends on the specific design requirements.

With the advent of EDA technology, the design of frequency dividers has undergone significant changes. This paper primarily discusses designing reference signal integer frequency dividers. When the electronic system receives a signal, it is assumed to be a clock signal, and its period and frequency are predetermined before processing. This signal is treated as a sensitive input and undergoes processing to generate four corresponding output signals. Meanwhile, an alarm bit signal needs to be configured within the relevant system, along with the corresponding counter, enabling the conversion of message numbers to achieve the design objective. The specific design process can be broken down into six steps:

(1) Launch the program and open an existing project, specifying the design type and specific requirements. Select an appropriate storage path, create a new folder if needed, and assign a name to the design folder, followed by loading the necessary file.

(2) Examine the model of the target chip and select the corresponding FPGA chip. Configure all parameters accordingly and invoke the relevant EDA tools based on the selected chip type.

(3) Construct hardware descriptors using auxiliary software. Navigate to the File menu, locate the New icon in the dialog box, input the corresponding language program, save the file, and assign a suitable filename based on its content. Proceed to compile by clicking the toolbar, and if any errors arise, they should be reviewed and corrected by the designer.

(4) After creating the document, generate a simulation waveform diagram. Follow similar steps as before, but when selecting the waveform file in the New menu, move the mouse icon to the blank area below and double-click to enter the emulation port selection.

(5) Simulate the selected simulation port by setting the simulation time, typically around 20 microseconds. In the clock dialog box, establish the start and run times, then select the high or low-level range. After these settings, exercise caution to protect against unintended changes and maintain consistency between names and files.

(6) Proceed with compilation settings to complete the waveform diagram compilation. Obtain the quadrature waveform with an equal duty cycle from the output port and adjust the technical state of the counter to achieve a variety of frequency divisions within the design.

3.4. Application of communication electronic circuit teaching experiment

The course of communication electronic circuits is a fundamental component of electronic information engineering, communication engineering, and related majors. Its primary objective is to delve into the analysis of essential functional elements commonly found in communication circuits. It aims to provide learners with an understanding of the operational principles and implementation of these circuits. Moreover, it introduces the principles and techniques involved in the linear and nonlinear applications of electronic circuits within analog signal processing systems. This comprehensive approach ensures that students acquire a solid foundation in communication theory, gain a systematic grasp of the working principles and analytical design of various functional units within communication systems, and establish a fundamental framework for theoretical engineering in communication and signal processing.

Traditionally, in the simulation of communication electronic circuits, physical circuits or experiment setups are often employed, accompanied by various instruments for testing, analysis, and calculation. Nonetheless, this method relies on experimental equipment with a certain level of precision, and the accuracy of instruments and equipment significantly influences the experimental results. In addition, circuit connection issues may also impact experimental accuracy. The use of simulation software for experimental teaching effectively mitigates these challenges. This paper centers on the discussion of Multisim2001 software, which proves highly beneficial for communication sub-circuit simulation experiments. Utilizing Multisim2001 software not only addresses the issue of experimental equipment accuracy affecting results but also expands the range of experiments in high-frequency circuits. This software enables precise control over amplitude, frequency, and phase values of input signals, substantially enhancing experiment accuracy and efficiency. Consequently, it plays a pivotal role in ensuring the reliability of experimental outcomes and significantly enhances the teaching environment in communication electronic circuit experiments. The application of simulation software, such as Multisim2001, can be employed in confirmatory experiments, comprehensive experiments, and development experiments [5].

A common step in the analysis and design of communication electronic circuits involves waveform and spectrum analysis of input and output signals. Multisim2001 proves to be exceptionally valuable for simulation analysis and testing in this regard. An example of the double-sideband modulation within communication electronic circuits is given here. This circuit is a critical component of transmitters in communication equipment, and its teaching holds significant importance. Due to the inherent complexities, including high calculation difficulty, intricate waveforms, and challenging observation of specific points, students often encounter difficulties in comprehending this topic during the teaching process. The use of Muhisim2001 simulation software alleviates these challenges. Its intuitive interface, user-friendly features, and powerful capabilities enable students to visually observe and analyze the input and output signals of the circuit, thereby gaining a deeper understanding of waveform and amplitude change.

4. Conclusion

The innovation of computer technology has provided technical support for the further development of the communication and electronics fields and has made important contributions to social and economic development. The application of EDA technology in communication electronic circuit design is a typical example, which optimizes the circuit design process, effectively improves the design efficiency, and reduces the failure rate in practical application, which is of great significance for the healthy development of the communication field.

Disclosure statement

The author declares no conflict of interest.

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