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SIMULATION & DESIGN OF DIAL TELEPHONE (DTMF 8870) CHIP IN HDL ENVIRONMENT

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Abstract - *The communication switching system enables the universal connectivity. The universal connectivity is realized when any entity in one part of the world can communicate with any other entity in another part of the world. In many ways telecommunication will acts as a substitute for the increasingly expensive physical transportation. The telecommunication links and switching were mainly designed for voice communication. With the appropriate attachments/equipments, they can be used to transmit data. A modern society, therefore needs new facilities including very high bandwidth switched data networks, and large communication satellites with small, cheap earth antennas.*

Speed and size are two important factors while designing the electronic system. It's Speed of operation and flexibility to modify, measures the performance of the system operation. Traffic handling capacity is an important element of service quality and will therefore play a basic role in this choice Microprocessor/microcontroller (MPMC) system can handle sequential operations with high flexibility and use of Field Programmable Gate Array (FPGA) can handle concurrent operations with high speed in small size area. So combined features of both these systems can enhance the performance of the system. High Performance Hybrid Telephone Network System (HTSS) is designed using combination of stored program control (SPC) and VLSI technology. Touch tone receiver follows DTMF (Dual tone Multifrequency) concept and Time division multiplexing is used for the call establishment for inter and intra communication.

***Key Words*:**
VHDL- Very High Speed Integrated Circuit
Hardware Description language
VLSI- Very Large Scale of Integration
ASIC- Application Specific Integrated Circuits
FPGA- Field Programmable Gate Array
CSA-Carry-save addition
MM-Montgomery modular multiplication,
RSA- Rivest–Shamir–Adleman (RSA) cryptosystem,
MEMS = Micro Electronics Mechanical System
MPMC = Microprocessor/microcontroller system

1. INTRODUCTION

Telecommunication networks carry information signals among entities, which are geographically far apart. An entity may be a computer or human being, a facsimile machine, a teleprinter, a data terminal and so on. The entities are involved in the process of information transfer which may be in the form of a telephone conversation (telephony) or a file transfer between two computers or message transfer between two terminals etc. Today it is almost truism to state that telecommunication systems are the symbol of our information age. With the rapidly growing traffic and untargeted growth of cyberspace, telecommunication becomes a fabric of our life. The future challenges are enormous as we anticipate rapid growth items of new services and number of users. What comes with the challenge is a genuine need for more advanced methodology supporting analysis and design of telecommunication architectures. Telecommunication has evaluated and growth at an explosive rate in recent years and will undoubtedly continue to do so.

The communication switching system enables the universal connectivity. The universal connectivity is realized when any entity in one part of the world can communicate with any other entity in another part of the world. In many ways telecommunication will acts as a substitute for the increasingly expensive physical transportation. The telecommunication links and switching were mainly designed for voice communication. With the appropriate attachments/equipments, they can be used to transmit data. A modern society, therefore needs new facilities including very high bandwidth switched data networks, and large communication satellites with small, cheap earth antennas.

Tele traffic Engineering (TTE) recommendations of Consultative Committee for Interactional Telephony and Telegraphy (CCITT), now International Tele-communication union (ITU) are intended to be international standards. Unlike signaling systems interfaces, or protocols, the necessity for standardization in this is not self-evident. However, standardization of grade of service (GOS) definitions, values, and relevant reference conditions seems to be necessary. TTE related activities in different ITU study groups try to satisfy many often contradicting demands. Future trends in telecommunication strongly support the view that attention of TTE studies in ITU would be desirable. In developed countries, users already faced an open market of telecommunication services. Size, price and quality of service are and will be the most important criteria in choosing this or that service provider.

2. TOUCH TONE DIAL TELEPHONE OBJECTIVE

Our objective is to simulate, modeling and design of Touch tone dial telephone receiver IC using HDL tool. VHDL is a strong hardware language which is used to describe the functionality of the hardware in the textual form. Touch tone receiver follows DTMF (Dual tone Multifrequency) concept and data transmission over the frequency dialing

(a) Parameters supporting to Chip development: FPGA implementation and chip validation includes: Synthesis Options Summary, VHDL Compilation, VHDL Analysis, Device utilization summary, Timing Report, Delay time calculation
(b) Hardware gauge parameters
(c) RAM Extraction, RAM Style, ROM Extraction, ROM Style, Mux Extraction, Mux Style, Decoder Extraction
(d) Priority Encoder Extraction, Shift Register Extraction, Logical Shifter Extraction , XOR Collapsing ,Resource Sharing ,Multiplier Style ,Automatic Register Balancing
(e) FPGA Implementation Parameters: I/O Buffers, Global Maximum Fan out, Generic Clock, Buffer (BUFG), Register Duplication, and Equivalent register Removal, Slice Packing, and Pack IO Registers into IOBs
(f) Output Parameters: The objective of this research work is to optimize/trade-off between speed, delay and cost. This will be judged by the below listed parameters: RTL Output, Write Timing Constraints, Slice Utilization Ratio, Slice Utilization Ratio Delta Total memory required to develop the chip.

3. DTMF DECODER WORKING

The DTMF keypad is laid out in a 4×4 matrix, with each row representing a *low* frequency, and each column representing a *high* frequency. Pressing a single key (such as '1') will send a sinusoidal tone for each of the two frequencies (697 and 1209 hertz (Hz)). The original keypads had levers inside, so each button activated two contacts. The multiple tones are the reason for calling the system multifrequency. These tones are then decoded by the switching center to determine which key was pressed.

DTMF keypad frequencies (with sound clips)

	1209 Hz	**1336 Hz**	**1477 Hz**	**1633 Hz**
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

3.1 Special tone frequencies:

National telephone systems define additional tones to indicate the status of lines, equipment, or the result of calls with special tones. Such tones are standardized in each country and may consist of single or multiple frequencies. Most European countries use a single precise frequency of 425 Hz, where the United States uses a dual frequency system.

Event	Low frequency	High frequency
Busy signal (US)	480 Hz	620 Hz
Ringback tone (US)	440 Hz	480 Hz
Dial tone (US)	350 Hz	440 Hz

The tone frequencies, as defined by the Precise Tone Plan, are selected such that harmonics and inter modulation products will not cause an unreliable signal. No frequency is a multiple of another, the difference between any two frequencies does not equal any of the frequencies, and the sum of any two frequencies does not equal any of the frequencies. The frequencies were initially designed with a ratio of 21/19, which is slightly less than a whole tone. The frequencies may not vary more than ±1.8% from their nominal frequency, or the switching center will ignore the signal. The high frequencies may be the same volume as – or louder than – the low frequencies when sent across the line. The loudness difference between the high and low frequencies can be as large as 3 decibels (dB) and is referred to as "twist." The duration of the tone should be at least 70 ms, although in some countries and applications DTMF receivers must be able to reliably detect DTMF tones as short as 45ms.

3.2 European Tones:

Event	Low frequency	High frequency
Busy signal (Most of Europe)	425 Hz	----
Ringback tone (UK & Ireland)	400 Hz	450 Hz
Ringback tone (Most of Europe)	425 Hz	----
Dial tone (UK)	350 Hz	450 Hz
Dial tone (Most of Europe)	425 Hz	----

As with other multi-frequency receivers, DTMF was originally decoded by tuned filter banks. Late in the 20th century most were replaced with digital signal processors. DTMF can be decoded using the Goertzel algorithm.

3.3 Telephone keypad buttons and frequency generation:

Figure 1.1A standard modern telephone keypad, as used for text messaging.

A **telephone keypad** is a keypad that appears on a "Touch Tone" telephone. It was standardized when the dual-tone multi-frequency system in the new push-button telephone was introduced in the 1960s, which gradually replaced the rotary dial. The contemporary keypad is laid out in a 4×3 grid, although the original DTMF system in the new keypad had an additional column for four now-defunct menu selector keys. When used to dial a telephone number,pressing a single key will produce a pitch consisting of two simultaneous pure tone sinusoidal frequencies. The row in which the key appears determines the *low* frequency, and the column determines the *high* frequency. For example, pressing the '1' key will result in a sound composed of both a 697 and a 1209 hertz (Hz) tone.

Table 1.1 DTMF frequency in upper and lower bands

DTMF Keypad Frequencies (with sound clips)			
1	2	3	**697 Hz**
4	5	6	**770 Hz**
7	8	9	**852 Hz**
*	0	#	**941 Hz**
1209 Hz	**1336 Hz**	**1477 Hz**	

Note that the layout of the digits is different from that commonly appearing on calculators and numeric keypads. The "*" is called the "star key" or "asterisk key". "#" is called the "number sign", "pound key", or "hash key", depending on one's nationality or personal preference. These can be used for special functions. For example, in the UK, users can order a 7.30am alarm call from a British Telecom telephone exchange by dialing: ***55*0730#**.

Most of the keys also bear letters according to the following system:

Figure1.2 A standard telephone keypad.

0 = none (in some telephones, "OPERATOR" or "OPER")
1 = none (in some older telephones, QZ)
2 = ABC
3 = DEF
4 = GHI
5 = JKL
6 = MNO
7 = PQRS
8 = TUV
9 = WXYZ

4. DESIGN ENVIRONMENT

The following diagram shows the basic steps for simulating a design in ModelSim.

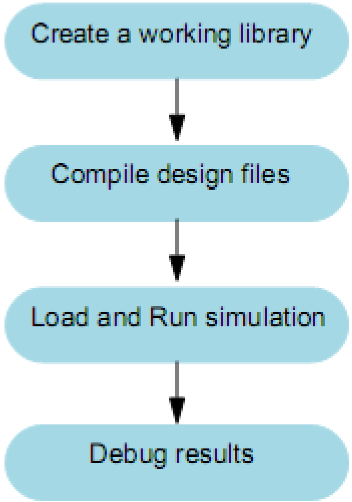

Figure 1.3: Chip Design Process Flow

- Creating the Working Library: In ModelSim, all designs are compiled into a library. Typically start a new simulation in ModelSim by creating a working library called "work," which is the default library name used by the compiler as the default destination for compiled design units.
- Compiling Design: After creating the working library, design is being compiled into it. The ModelSim library format is compatible across all supported platforms.
- Loading and Running the Simulator with the Design: With the design compiled, we load the simulator with design by invoking the simulator on a top-level module (Verilog) or a configuration or entity/architecture pair (VHDL). Assuming the design loads successfully, the simulation time is set to zero, and you enter a run command to begin simulation.
- Debugging: ModelSim's robust debugging environment is used to track down the cause of the problem.

5. RESULT

Figure 1.4 (a) shows the result of touch tone receiver with dialing pulses and data .

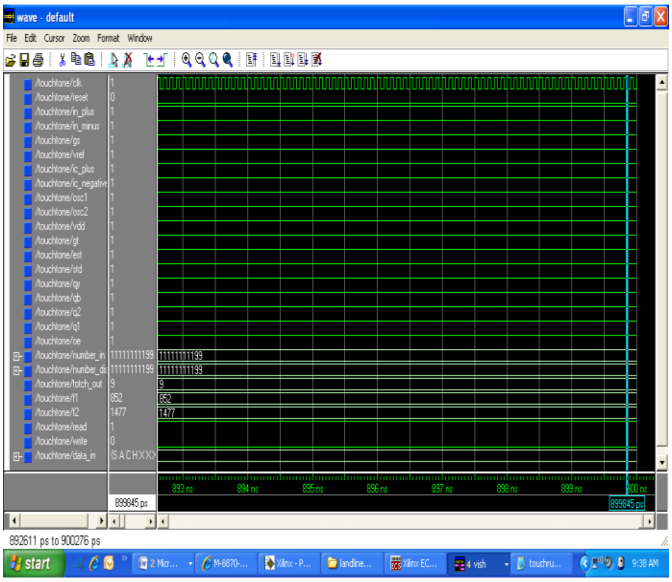

Figure 1.4 (a) Touch tone receiver output

6. CONCLUSIONS

Simulation and synthesis of Touch tone dial telephone is done and is done. The call establishment in the telecommunication switching environment for intra and inter communication is also done.

Presently switching systems uses multiplexers, routers, switches etc that leads to low efficiency as they are analog in nature and have a high power requirement. In contrast we have tried to make this whole system digital to increase the efficiency, lower the power requirement, and reduce the delay. VHDL has been used to write all the programs for the IC's because of its user-friendly nature and thus modifications if required for further development shall not prove to be an obstacle.

As we know, the process of making IC's is time consuming and an expensive venture so we must be sure about the working results of the IC's in advance as we can't accept errors later. Thus the project focuses on simulation prior to fabrication. Burning these programs on FPGA (Field Programmable Gate Array) will help us to see the functional design of ICs. These results in addition to the systematic view generated would help us to design Application Specific AS IC. This project realizes protocols on a chip. This project is a significant effort towards total digitization of switching exchanges and would surely prove a boon for VLSI design industry.

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