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"DTMF Detection from Goertzel's Algorithm"

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Abstract: **Dual-tone multi-frequency (DTMF) is an international signaling standard for telephone digits(number buttons). These signals are used in touch-tone telephones as well as many other areas. Since analog devices are rapidly changing with digital devices, digital DTMF decoders become more important. The subject of this paper is to build a dual-tone multi-frequency(DTMF) signal detector. There are many algorithms for DTMF detection, and among all of them the chosen one is Goertzel's algorithm. It is one of the simplest algorithms of all and it is very often used in practical realizations. We have used the Altera DE2-115 board comprising of AUDIO CODEC,FPGA chip, RAM,SD Card etc. First the DTMF(Dual Tone Multi Frequency)signal is passed through AUDIO CODEC where the analog signal is converted to digital signal. Then the samples obtained are passed through a bank of goertzel filters loaded on FPGA,where the frequency is detected. simulations are carried out using quartus II tool and RTL code of verilog.**

Keywords: **-- Pulse dialing, Tone dialing, Push button tone dialing, Digital frequency spectrum, Fast Fourier spectrum, Goertzel algorithm.**

I. INTRODUCTION

In telecommunication, a caller needs to dial the number of the callee. The earlier versions of telephones used to have rotator type dials which are now obsolete. Almost all the landline and mobile phone handsets now use pushbutton keypads.

Fig(1)

DTMF is a signaling system for identifying the keys or better say the number dialed on a pushbutton or DTMF keypad. The early telephone systems used pulse dialing or loop disconnect signaling. This was replaced by multi frequency (MF) dialing. DTMF is a multi frequency tone dialing system used by the push button keypads in telephone and mobile sets to convey the number or key dialed by the caller. DTMF has enabled the long distance signaling of dialed numbers in voice frequency range over telephone lines. This has eliminated the need of telecom operator between the caller and the callee and evolved automated dialing in the telephone switching centers.DTMF (Dual tone multi frequency) as the name suggests uses a combination of two sine wave tones to represent a key. These tones are called row and column frequencies as they correspond to the layout of a telephone keypad.

II. DTMF GENERATION

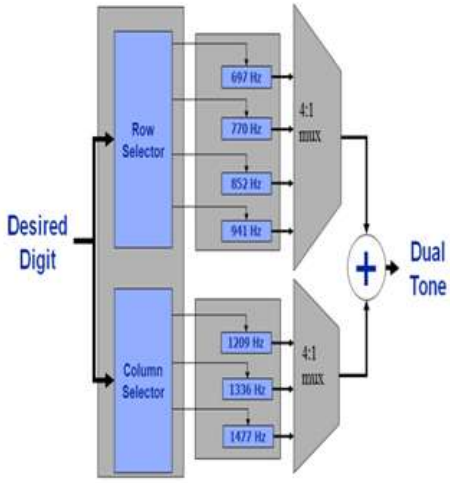

Fig 2. DTMF generator

A DTMF keypad (generator or encoder) generates a sinusoidal tone which is mixture of the row and column frequencies. The row frequencies are low group frequencies. The column frequencies belong to high group frequencies. This prevents misinterpretation of the harmonics. Also the frequencies for DTMF are so chosen

that none have a harmonic relationship with the others and that mixing the frequencies would not produce sum or product frequencies that could mimic another valid tone. The high-group frequencies (the column tones) are slightly louder than the low-group to compensate for the high-frequency roll off of voice audio systems. The row and column frequencies corresponding to a DTMF keypad have been indicated in the below figure.

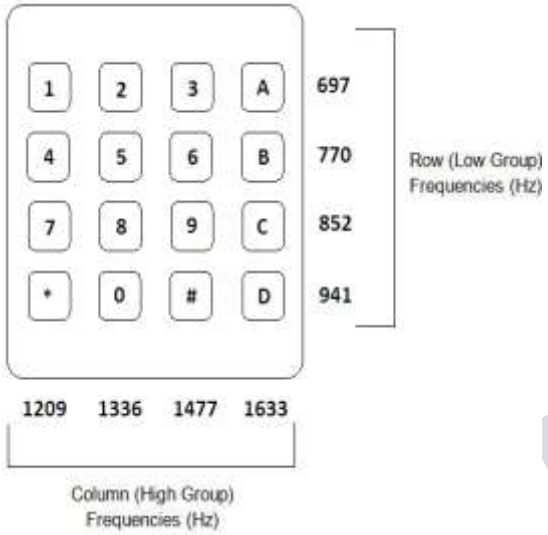

Fig 3. DTMF Keypad

III.FREQUENCY DETECTION TECHNIQUES

A. Goertzel Algorithm

There are some applications where some only a selected number of values are desired but the entire DFT is not required. In such case, the FFT algorithm may no longer be more efficient than the direct computation of the desired values of DFT. In fact the desired number of values of the DFT is less than logN to base2,a direct computation of the desired values is more efficient.The direct computation of DFT can be formulated as a linear filtering operation on the input data sequence. The linear filtering approach takes the form of a parallel bank of resonators where each resonator selects one of the frequencies wk=2pik/N, k=0,1….N-1,corresponding to N frequencies in the DFT.

The Goertzel Algorithm is particularly attractive when the DFT is to be computed at a relatively small number M of values, where M<=logN to base2.

IV ARCHITECTURE OF DTMF DETECTOR

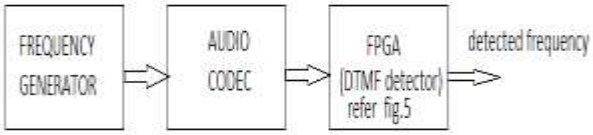

Fig 4 Architecture of DTMF detector.

Fig 4 shows the architecture of DTMF detector which consists of frequency generator, Audio codec, FPGA on which filter program is loaded. DTMF (Dual tone multi frequency) as the name suggests uses a combination of two sine wave tones to represent a key. These tones are called row and column frequencies as they correspond to the layout of a telephone keypad (refer fig 1.3). A DTMF keypad (generator or encoder) generates a sinusoidal tone which is mixture of the row and column frequencies. The row frequencies are low group frequencies. The column frequencies belong to high group frequencies. This prevents misinterpretation of the harmonics. Also the frequencies for DTMF are so chosen that none have a harmonic relationship with the others and that mixing the frequencies would not produce sum or product frequencies that could mimic another valid tone. The high-group frequencies (the column tones) are slightly louder than the low-group to compensate for the high-frequency roll off of voice audio systems. The row and column frequencies corresponding to a DTMF keypad have been indicated in the Fig 3. Audio codec (WM8731) chip will digitize the DTMF signal. These digitized samples are then given to the bank of goertzel's filter is as shown in the fig 5..Row and column frequency Goertzel's filters are arranged separately so that combination of row and column frequency detected will decide which number is pressed.

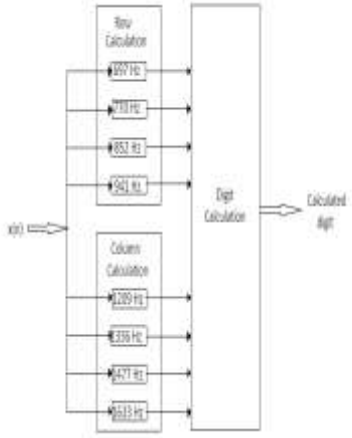

Fig .5 DTMF detector

Why not computer signals instead of DTMF

Radio signals are mostly analog and they are optimized for voice signals. DTMF was designed by the engineers to be in the normal human voice range.What this means is that DTMF passes transparently over normal two-way radio channels, narrow-band or wide-band. It doesn't require special channel widths, or expensive equipment. In most instances you can simply attach a cable to the speaker output of your two-way radio to a decoder, and it will be ready to go. Its straightforward, fast, easy to understand,

works on most any type of radio, and gives the most flexible features for the lowest cost!

V CONCLUSION

DTMF (Dual-Tone Multi-Frequency) detector is carried out successfully using Goertzel filters. The eight Goertzel filters and I2C bus communication between audio codec and FPGA are implemented by writing verilog code. ADC required for sampling is used from Audio codec. The number pressed at the transmitter side is decided from the frequency detected at the receiver side using Goertzel filters. The threshold energy was set and the Phone numbers were detected using the Goertzel Algorithm. PhoneNumberA = 8 8 2 3 0 9 6 Phone number B= 4 4 3 4 5 0 0 . The future work of this is to implement DTMF detector in CADENCE

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