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Digital Number System Calculator Using Intel Atom Kit

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Abstract- A number system is a set of rules & symbols used to represent a number. And, a number system calculator is a software calculator used to perform mathematical computations on number systems. The knowledge of number systems, their representation, arithmetic, compliments and inter-conversion of numbers between prescribed number systems is essential for understanding of computers and successful programming for digital devices. Understanding all these number systems and related terms/concepts requires allot of time and a large number of techniques to expertise. To overcome this problem, we propose calculating software which will cover and perform all the prescribed calculations within a fraction of second using Intel Atom Kit: The Inforce® SYS940X-01 with Linux as Operating System has capability of performing many applications. In this work its performance for various operations like, arithmetic's, conversion from one to another system and the compliments of number in any required system is shown. Four most common number systems taken under the consideration are binary, octal, decimal, and hexadecimal.

Keywords- Conversion, Number System, Calculator, Intel Atom Kit, Linux.

I. INTRODUCTION

Modern civilization is well familiar with decimal number system using ten digits and as it perform the computations since childhood, using the digits 0 – 9. However when it deals with computers it require to be familiar that how a number will be used. In digital world, most commonly computer science and IT normally we requires a working knowledge of various number systems, four basic/most common of these are binary i.e (0,1), octal with eight digits i.e. (0 to 7), decimal with ten digits i.e (0 to 9) and hexadecimal with digits from 0 to 9 and alphabets from A to F. These all number systems use unique and distinct symbols. Some of these use only numeric digits (0, 1, 2... 9), while other use alphabets as well along the numeric digits. In case of hexadecimal system, digits 10-15 are designated as A to F to avoid confusion with the decimal numbers, 10 to 15[1].

The knowledge of number system is not enough to understand the computers. In various digital telecommunication technologies, we often need to change the simple signal into a pattern recognizable to the sender and receiver as representing the information intended. To be carried from one place to another, data are usually converted to digital signals. Sometimes we need to convert an analog signal (such as voice in a telephone conversation) into a digital signal and vice versa. So, in many applications we deal with the inter conversion of number systems [4-5]. Every system can be converted to another, but each conversion often takes place in a different way, using a different technique. There are various techniques that are used for these inter conversions.

Also to perform many applications we need to perform various operations on binary numbers, which if done manually will consume a lot of time and will be prone to error. These operations are addition, multiplication, 1's compliment of a binary number, 2's compliment of a binary number [2].

A. Hardware Used

Intel atom

The Inforce® SYS940X-01 Portable Computing Platform is a highly-integrated processor system that provides rich and flexible features to embedded and mobile system designers. Based on Intel® Atom™ technology specifically created for ultra-mobile computing, the SYS940X-01 offers outstanding performance in a small form-factor to optimize solutions for a variety of portable and fixed installation applications. The SYS940X-01 platform supports Microsoft Windows XP and out-of-the-box Linux operating systems. Developers can leverage thousands of applications and tools that are already available for the PC desktop to accelerate their development cycle and time-to-market.

The Intel Atom Processor E6xx Series is the next-generation Intel architecture (IA) CPU for the small form factor ultra-low power embedded segments based on a new architecture partitioning. The new architecture partitioning integrates the 3D graphics engine, memory controller and other blocks with the IA CPU core.

The processor departs from the proprietary chipset interfaces used by other IA CPUs to an open standard, industry-proven PCI Express v1.0 interface. This allows it to be paired with customer defined IOH, ASIC, FPGA and off-the-shelf discrete components. This provides utmost flexibility in IO solutions. This is important for deeply embedded applications, in which IOs differ from one application to another, unlike traditional PC-like applications. Table 1 shows features of Intel atom kit E6xx series [9].

Table 1: System Features

Form Factor	ECX (146 millimeters[5.7 inches] x 102 millimeters [4.0 inches])
Processor	Passively-cooled, soldered-down Intel® Atom™ Processor E6xx,600MHz to 1.6GHz
Main Memory	512MB-1GB of DDR2 800 MHz system memory
Chipset	Intel® Platform Controller Hub EG20T PCH
Display	• LVDS • SDVO – VGA ASIC – CH7317 A from Chrontel
Audio	Intel® High Definition Audio • Microphone/Headphone header, Buzzer • Audio Codec – ALC232 from Realtek
Expansion	x1 Mini PCI Express slot
Storage	• Two SATA 2.0 ports (3Gb/s per port) • x1 SD Card Slot
Peripheral Interfaces	• x2 RS-232 • x5 USB 2.0 Host ports • x1 SPI header
Debug Ports	x1 LPC header
BIOS	• Phoenix BIOS • Intel BLDK1 • Intel BLDK2
LAN Support	Gigabit Ethernet
Power	+12V / 1.5A Input Socket
Power Management	Support for Advanced Configuration and Power Interface (ACPI)
Environment	• Operating Temperature: 0oC to 55oC • Storage Temperature: -20oC to 85oC • Relative Humidity: 5% to 95%, non-condensing • RoHS compliant • REACH: In progress • WEEE
Safety	• UL 60950-1, 2nd Edition, 2007-03-27 (Information Technology Equipment - Safety - Part 1: General Requirements)
	• CSA C22.2 No. 60950-1-07, 2nd Edition, 2007-03 (Information Technology Equipment - Safety - Part 1: General Requirements)

Linux

Linux was originally developed for personal computers based on the Intel x86 architecture, but has since been ported to more platforms than any other operating system. Because of the dominance of the Linux based Android on smartphones, Linux also has the largest installed base of all general-purpose operating systems. Linux also runs on embedded systems, i.e. devices whose operating system is typically built into the firmware and is highly tailored to the system. This includes routers, automation controls, smart home technology, televisions, automobiles digital video recorders, video game consoles, and smartwatches. Linux is one of the most prominent examples of free and open-source software collaboration. Figure 1 shows the block diagram of Linux operating system.

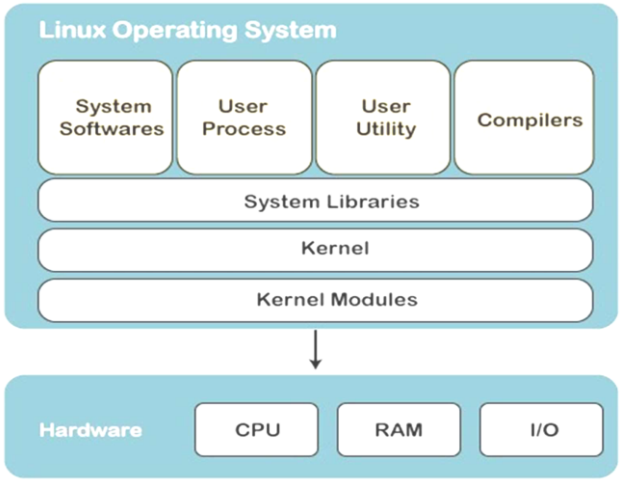

Figure 1: Block diagram for Linux operating system

B. Related Work

[7] Illustrated different methods of conversions of one system to another. Description of fundamentals of number system is given by [1-2, 6]. [3] Tabulated the various

II. METHODOLOGY

A. Compiler used:

In Linux, the GCC stands for **GNU Compiler Collection**. It is a compiler system for the various programming languages. It is mainly used to compile the C and C++ programs. It takes the name of the source program as a necessary argument; rest arguments are optional such as debugging, warning, object file, and linking libraries.

Figure 2 shows the procedure followed to build digital software calculator.

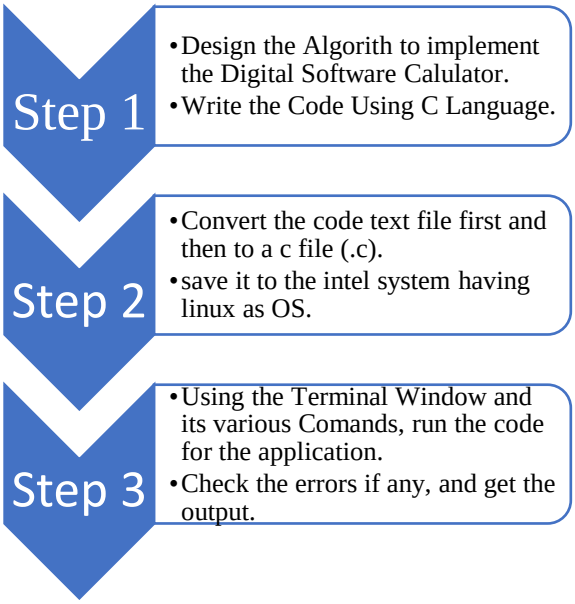

Figure 2: Procedure Followed

B. Algorithm:

// DECIMAL TO others [BINARY, OCTAL, HEXADECIMAL]
$(==)_{10}$ → $(==)_{2,8,16}$
Integer: repeated division method
Fraction: repeated multiplication method

//BINARY TO others [OCTAL, HEXADECIMAL]
$(==)_{2}$ → $(==)_{8,16}$
To octal: replace group of 3-binary bits by octal digit
To hex: replace group of 4-binary bits by hexadecimal digit
(same method for both integral and fraction part)

//OCTAL TO HEXADECIMAL
$(==)_{8}$ □ $(==)_{16}$
Direct conversion not applicable
Octal → Decimal → Hexadecimal

//Others [BINARY, OCTAL, HEXADECIMAL] TO DECIMAL
$(==)_{2,8,16}$ → $(==)_{10}$
Integer: sum of [(+ve weights) × (integer)]
Fraction: sum of [(-ve weights) × (fraction)]

//Others [OCTAL, HEXADECIMAL] TO BINARY
$(==)_{8,16}$ → $(==)_{2}$
From octal: replace each octal digit by 3-bit binary
From hex: replace each hexa-decimal digit by 4-bit binary
(Same method for both integral and fraction part)

//HEXADECIMAL TO OCTAL
$(==)_{16}$ □ $(==)_{8}$
Direct conversion not applicable
Hexadecimal → Decimal → Octal

//BINARY ADDITION
1+1 → sum= 0, carry= 1
1+1+1 → sum= 1, carry= 1

//BINARY MULTIPLICATION
Perform single bit multiplication → shifted addition

//1's COMPLIMENT
Toggle the digits

//2's COMPLIMENT
Perform 1's compliment and add 1 to it.

III. RESULTS

Figure 3 shows the out of the complier, which asks the no. options that can be calculated using the software. There are nine task that can be performed.

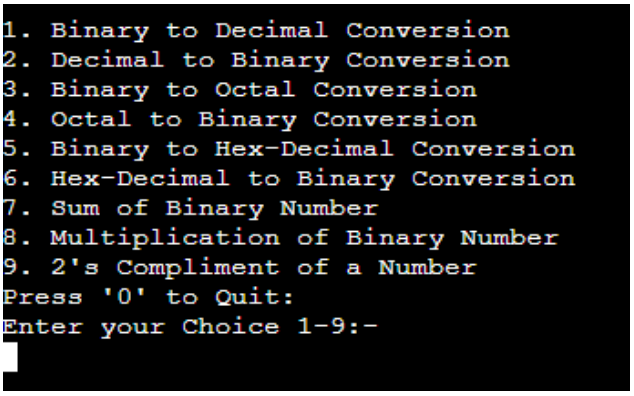

Figure 3: Complier Ask to Perform the Desired

Figure 4 shows the 2nd operation's result after calculating the decimal (55) to a binary value (110111) and figure 5 shows the 8th operation's result after calculating the multiplication of two binary numbers i.e. 1010 * 0011 = 11110

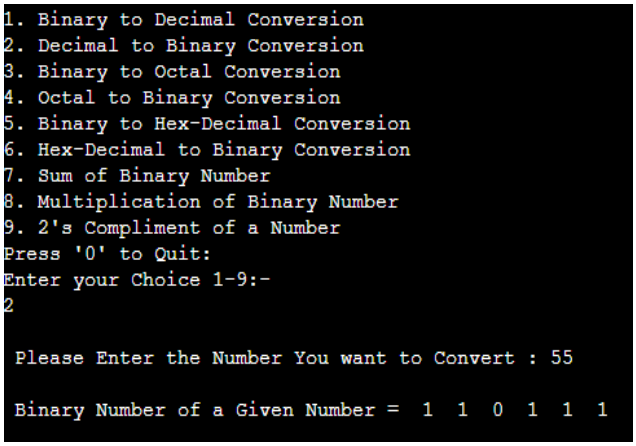

Figure 4: Performing Decimal to Binary Conversion

Figure 5 shows the result after multiplication of two binary numbers.

```
1. Binary to Decimal Conversion
2. Decimal to Binary Conversion
3. Binary to Octal Conversion
4. Octal to Binary Conversion
5. Binary to Hex-Decimal Conversion
6. Hex-Decimal to Binary Conversion
7. Sum of Binary Number
8. Multiplication of Binary Number
9. 2's Compliment of a Number
Press '0' to Quit:
Enter your Choice 1-9:-
8
Enter the first binary number: 1010
Enter the second binary number: 0011
Product of two binary numbers: 11110
```

Figure 5: Performing Binary Multiplication

Thus in this way it has become easier to perform various operations with a fraction of time without any errors.

IV. CONCLUSION

The work done in this paper is a software package, which can be used in calculations to perform different binary operations and conversion of one number system to another as shown in the results. Almost all modern technology and computers use the digital number system due to its ease of implementation in digital circuitry using logic gates. Thus to understand the processing of these systems one need to study digital number system and their conversions. While performing these one also need to get hands on with Intel atom kit using Linux as its operating system. The Intel Atom Processor E6xx Series is the next-generation Intel architecture (IA) CPU for the small form factor ultra-low power embedded segments based on a new architecture partitioning. This system is capable of performing various applications. Thus implementation of digital calculator on this platform will help many users to understand digital number system. This calculator application is capable of performing the following nine functions in a single platform.

1) Binary to Decimal conversion
2) Decimal to Binary conversion
3) Binary to Octal conversion
4) Octal to Binary conversion
5) Binary to Hexa- Decimal conversion
6) Hexa- Decimal to Decimal conversion
7) Addition of Binary Numbers
8) Multiplication of Binary Numbers
9) 1's and 2's Compliment

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