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Investigation of Geographical impact on Power Dissipation during simulation of Electronics Design on 28nm FPGA

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Abstract

In this paper, we are taking temperature of 17th October 2015 afternoon (12:00-1:00 Indian Time) of all different Asian countries without considering their local time. We simulate our design by providing environment temperature of all these capital cities and observe the change in leakage power dissipation with change of temperature. This work is novel work that demonstrates change in power dissipation if device will migrate from one country to another. Here, we are using Artix-7 FPGA and ROM as a basic electronic design to demonstrate variation in leakage power dissipation. We observe that Ulaanbaatar is the coldest Capital i.e. having least temperature and it should be noted down that power consumption is also minimum. Similarly capital of UAE has highest temperature and power consumption is also high.

1. Introduction

It is well known that most of electronic devices are temperature sensitive and the amount of power consumed by them as well as their performance varies according to the environmental conditions such as temperature, humidity etc. In order to check the amount of power dissipated at different temperatures simulation is done. Temperatures of different capitals Asian countries are observed as per the Indian time and the power consumption is noted down. Artix-7 family of field programmable gate arrays is used which is designed to consume almost half the power as compare to previous generation when they are provided with advanced functionality. When we use electronic devices at different locations there is change in their performance due to different environmental conditions and it is important to figure out how power consumption of these devices changes. To resolve and make these power issues familiar this work has been done. The same device may consume different power at different capital cities according to the temperature of the country. Field programmable gate arrays are semiconductor device and are affected by the variation in geographical conditions. Reliability, speed as well as power are affected by change in temperature. Various factors in semiconductors that are dependent on temperature are as shown in Figure 1. In this work, we have taken temperature of capital of 49 Asian countries and we have observe that Abu Dhabi has the highest temperature and Ulaanbaatar had the lowest temperature

on our specific time. Similarly power dissipation was the highest for Abu Dhabi and lowest for Ulaanbaatar as shown in Table 1.

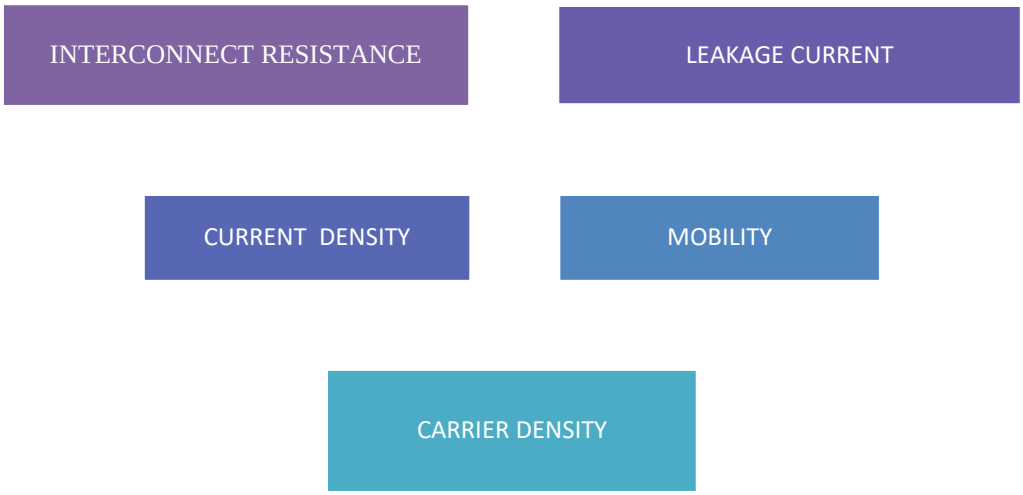

Figure 1: Factors dependent on temperature

2. Related Works

Semiconductor devices are temperature dependent and this also has impact on power consumption as discussed that's why for proper operation of electrical devices this area needs to be worked upon. This field is related to the work that has already been done in the area of difference in power due to geographical factors and somewhat different from the work done by us. The Southern sections of the Asian continent are hot, whereas northeastern areas such as Siberia are very cold. East Asia has a temperate climate. The highest temperature recorded in Asia was 54.0 °C at Tirat Tsvi, Israel on June 21, 1942 [1]. The lowest temperature measured was −67.8 °C (−90.0 °F) at Verkhoyansk and Oymyakon, both in Sakha Republic of Russia on February 7, 1892 and February 6, 1933 respectively [2]. Some of papers related to our work are like Lifetime Reliability Enhancement of Microprocessors: Mitigating the Impact of Negative Bias Temperature Instability [3]. This paper deals with management of negative bias temperature instability. There is also work going on in research of temperature effects on micro-and nano-electronic devices [4]. In USA, there was also survey conducted to study the effects of regional temperature on electric vehicle efficiency, range, and emissions [5]. Some researcher also working to study the impact of urban heat island and global warming on the power demand and electricity consumption of buildings [6]. Work discussed in [3-6] is on macro level. On micro level where target is 90-28nm FPGA, there are different works also going on to study the effect of temperature on leakage power dissipation like IoTs Enable Active Contour Modeling [7], Thermal Mechanics Based Energy Efficient FIR Filter [8].

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3. Observation

Table 1 : Power and temperature readings of different capitals

Countries	Capital	Power (in Watt)	Temperature As on 17th October Noon
Afghanistan	Kabul	0.041	23
Armenia	Yerewan	0.037	16
Azerbaijan	Baku	0.035	13
Bahrain	Manama	0.048	32
Bangladesh	Dhaka	0.048	32
Bhutan	Thimpu	0.037	17
Brunei	Bandar Seri Begawan	0.045	28
Cambodia	Phnom Penh	0.049	33
China	Beijing	0.040	22
Cyprus	Nicosia	0.045	28
Georgia	Tabilis	0.034	11
India	Delhi	0.050	34
Indonesia	Jakarta	0.053	36
Iran	Tehran	0.036	15
Iraq	Bagdad	0.047	31
Israel	Jerusalem	0.045	28
Japan	Tokyo	0.038	18
Jordan	Amman	0.043	26
Kazakhstan	Astana	0.033	8
Kuwait	Kuwait City	0.051	35
Kyrgyzstan	Bishkek	0.035	13
Laos	Vientiane	0.049	33
Lebanon	Beirut	0.044	27
Malaysia	Kuala lumpur	0.043	26
Maldives	Male	0.047	31
Mongolia	Ulaanbaatar	0.031	2
Myanmar	Naypyitaw	0.047	31
Nepal	Kathmandu	0.042	24
North Korea	Pyongyang	0.037	17
Oman	Muscat	0.050	34
Pakistan	Islamabad	0.046	30
Palestine	Ramallah	0.046	29
Phillipines	Manila	0.44	27
Qatar	Doha	0.050	34
Saudi Arabia	Riyadh	0.048	32
Singapore	Singapore	0.049	33
South Korea	Seoul	0.042	24
Sri Lanka	Srijaywardenepura Kotte	0.046	30
Syria	Damascus	0.043	26
Taiwan	Taipei	0.043	26
Tajikistan	Dushanbe	0.042	24
Thailand	Bangkok	0.049	33
Timor-Leste	Dili	0.044	27
Turkey	Ankara	0.037	17
Turkmenistan	Asgabat	0.034	10
UAE	Abu Dhabi	0.054	37

Uzbekistan	Tashkent	0.035	12
Vietnam	Hanoi	0.048	32
Yemen	Sanaa	0.041	23

Table 1 show temperature of capital of 49 asian countries and power dissipatio of ROM when we provide same external temperature during implementation of ROM.

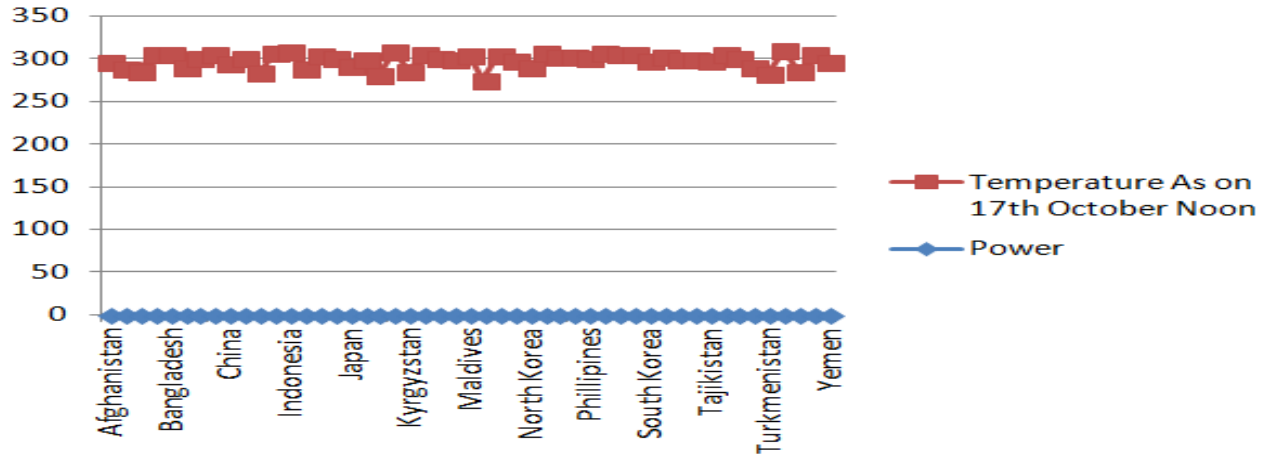

Fig 2: Graph of Power and Temperature (in Kelvin)

Table 1 covers different temperature of capital cities of all Asian countries and its corresponding temperature in degree Celsius and power dissipation in Watt of ROM, when we implement this design on Artix-7 FPGA.

a. Top 10 Hottest Capitals of Asian Countries

In this sub section, our focus in only on the top 10 hottest capitals of Asian countries. On 17th October 2015 (2:00 AM Indian Standard Time), Phnom Pehn capital of Cambodia, Vientiane of Laos, Singapore, and Bangkok of Thiland had the lowest of 33 degree Celsius and Abu Dhabi capital of UAE had the highest temperature of 37 degree Celsius as shown in Table 2. Therefore, leakage power dissipation was highest for Abu Dhabi. Figure 3 shows temperature in degree kelvin.

Table 2: Table of hottest capitals of Asian Countries

Countries	Capital	Power(in Watt)	Temperature As on 17th October Noon
Cambodia	Phnom Penh	0.049	33
India	Delhi	0.050	34
Indonesia	Jakarta	0.053	36
Kuwait	Kuwait City	0.051	35
Laos	Vientiane	0.049	33
Oman	Muscat	0.050	34
Qatar	Doha	0.050	34

Singapore	Singapore	0.049	33
Thailand	Bangkok	0.049	33
UAE	Abu Dhabi	0.054	37

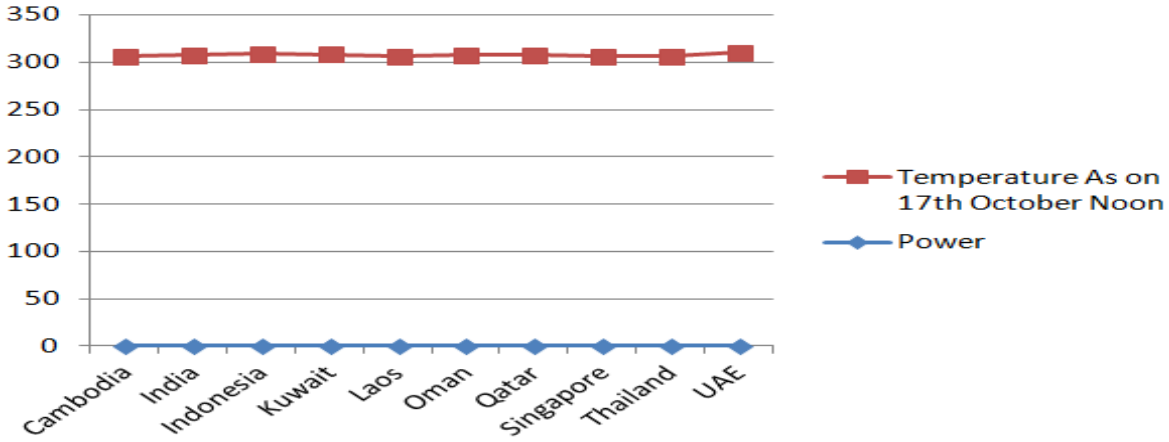

Fig3: Graph of Power and Temperature (in Kelvin) for hottest capitals

b. Top 10 Coldest Capitals of Asian Countries

Asia is primarily considered as continent of highest temperature. Whereas, Ulaanbaatar of Mongolia had the minimum temperature among top 10 coldest capital of Asian countries. Astana stand on the second place with ambient temperature of 8 degree celsius. Thimpu of Bhutan had the maximum temperature among top 10 coldest capital of Asian countries as shown in Table 3 and Figure 4.

Table 3: Table of coldest capitals of Asian Countries

Countries	Capital	Power(in Watt)	Temperature As on 17th October Noon
Armenia	Yerewan	0.037	16
Azerbaijan	Baku	0.035	13
Bhutan	Thimpu	0.037	17
Georgia	Tabilis	0.034	11
Iran	Tehran	0.036	15
Kazakhstan	Astana	0.033	8
Kyrgyzstan	Bishkek	0.035	13
Mongolia	Ulaanbaatar	0.031	2
Turkmenistan	Asgabat	0.034	10
Uzbekistan	Tashkent	0.035	12

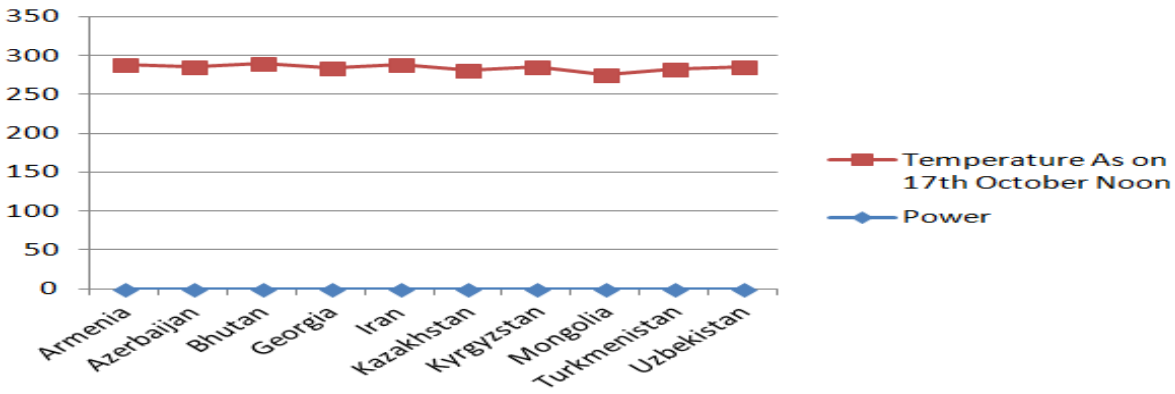

Fig 4: Graph of Power and Temperature (in Kelvin) of coldest capitals

4. Conclusion

From all the readings and graphs it is clear that there is change in the power dissipation with respect to temperature. According to the table it can be seen that Ulaanbaatar is the coldest Capital i.e. having least temperature and it should be noted down that power consumption is also minimum. Similarly capital of UAE has highest temperature and power consumption is also high. It can be concluded that power consumption increases with increase in temperature and device performance may vary from place to place. At single instant of time a same device can perform different in various countries. So the work can be done to make devices better in case of their sensitivity in with respect to geographical conditions. Performance of device should be precise and must consume least amount of power as possible. Power consumption is measure of how much power is used by an appliance in watts and that varies with length of time for which device is used, geographical conditions and life of components used etc and these factors should be taken care of to make devices efficient.

5. Future Scope

In the following paper the work has been done on Artix-7 FPGA and basic design of ROM and further the work can be done using various families of FPGA. Results can be observed for different frequencies, for different IOs and for different capacitance. An efficient approach can be developed in order to make the devices that can function in the same manner without considering the problem of power. Otherwise appliances can perform according to the geographical condition and this will have a great impact on the output of the device or it may be possible that even the device will stop working where the difference in environmental conditions is huge.

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