ISSN 2320-9984
Volume 5 Issue 2 | June 2017 ISSN: 2320-9984 (Online)
International Journal of Modern Engineering & Management Research
Website: www.ijmemr.org

Ambient Power Supply Driven VHDL – CPLD Implementation of Data Acquisition System

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Abstract**—***The new concept to generate power for low voltage operating modules and devices based on converting the radio frequencies and ambient noise power from atmosphere into usable electrical power is proposed. Recent technological development would make people like the concept of getting power without wire; this brings up interesting concepts of power generation which harness the atmospheric contaminants and other unknown but interesting resources. The proposed concept uses fundamentals of energy scavenging, that collect the radio noise present in radio frequencies and from different other sources and converts it to usable power. In recent days extreme low power devices are available because of technique: Surface MountDevice Technology and integration techniques, which are being used in the design so that maximum power can be generated and can be further utilized. For demonstration of strength of Ambient Power Source application of Data Acquisition is realized using low power VLSI – CPLD device which monitor the temperature of the atmosphere and displays the data on controlling computer using serial communication protocol.*

Keywords:— *Ambient Power Supply, CPLD, FPGA, VHDL, Data Acquisition*

1. INTRODUCTION

In recent days several novel researches are investigated for generation of electrical power as an alternative to the one, like generation using hydrocarbon fueled system and portable battery sources. To fulfill the need of power supply researchers are mainly interested in converting the readily available natural resources to electrical power supply. This concept of producing electrical energy is called as "**Ambient Power Supply"**.

Ambient **P**ower **S**ource gives us the concepts of generating the electrical power supply from the natural resources like Air - Windmill, Natural Water Flow – Running Turbines, power from Transmission Lines, Solar Energy – Using Solar Panels – most popular concept, thermal storage batteries, and most recent technique of energy generation using chemical – Adenosine Tri-Phosphate – which is available on the green leaves. After using these fundamentals of energy conversion for real time applications it is found that some of they are time dependent, higher installation cost, requires frequent maintenance and sometimes they are not reliable apart from this, battery weight, life and the logistic of fuel resupply often limit the capabilities and life of applications. Here need arises for the one such invention which can overcome such drawbacks and effectively produce the electric power supply.

Electrical power generation using the noise present in the atmosphere, from the radio wave is the best solution over other traditional power generation techniques. In the proposed concept long wire antenna is used, placed at certain distance from ground, allowed to receive different usable and unusable frequencies including radio waves, seismic waves and even different noise, which further induces current in antenna wire – a fundamental of electromagnetic induction – when connected to the bank of capacitor and diode becomes excellent power source.

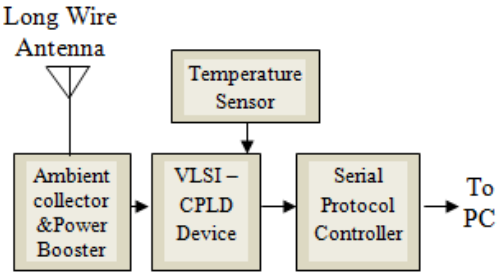

Figure 1:Proposed Block Diagram

2. LONG WIRE ANTENNA

A Long wire antenna is placed at approximately 50 feet above the ground According to the fundamentals of electromagnetic field induction the power induces in the wire of antenna. Current flowing in the antenna produced voltage across the antenna terminals. Voltage developed is of the order of few mill volts which require power boosting before being use for real time applications.

Ambient Power Booster:

For Ambient power collection simple rectifier circuit can be designed as shown in figure2. At the AC side antenna output is connected with earth ground and at the dc side we connect capacitors which help to build the necessary voltage.

Once the power is collected it can be applied to the Power Booster Circuit, power booster is basically bank of capacitors which when connected with combination of diodes acts as a power booster. Sometimes the power booster is also called as voltage doublers. For better power boosting two stage voltage doubler is used in which output of one doubler is connected in series with the other. Such arrangement maximizes the output voltage without transformer.

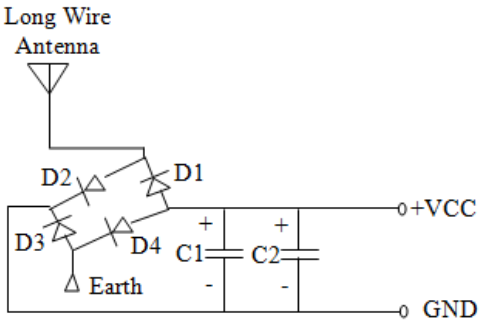

Figure 2: Rectifier Circuit

As shown in the figure D1, D2, D3, D4 are the simple 1N4007 PN junction diode, connected to form full wave bridge rectifier. Instead of going for half wave rectifier, full wave is preferred only because of better rectification. C1 and C2 are the 25µf/470V capacitors which build the required voltage output.

At the output of the antenna we AC power which can be measured by connecting Digital Multimeter with selection knob set to the AC mode. Depending upon the parameters like type of antenna, Height at which antenna is placed and with the help of Ambient Power Booster circuit we get power ranging from minimum 2V to 30V or even more.

Recent integration technology of surface mount devices have developed active and passive devices that are working on least power, these devices can be employed in the power booster circuit so that power consumption of the rectifier and power booster circuit can be reduced upto minimum level.

Temperature Sensor:

For measurement of the temperature changes in the atmosphere different sensors are available like thermistor and integrated

sensors. Out of which precision centigrade temperature sensor is used because it is possible to measure the temperature more accurately than thermistor, sensor circuit is integrated inside the chip and therefore is not subject to oxidation, Integrated sensors generates higher output voltage than thermocouple and hence no need to have extra circuitry for amplification. Because of all such features LM35 series sensor is most suitable for our application.

LM35 is Integrated Circuit temperature sensor, whose output voltage is linearly proportional to the centigrade temperature. Such sensor reduces the efforts of complex scaling and calibration process. Apart from this LM35 series temperature sensor doesn't require any external trimming for accuracy adjustments.

LM35 comes in various packages like TO – 92 plastic transistors like package, TO – 46 metal-can-transistors like package, 8-lead surface mount SO-8 small outline package and TO-202 package. One can be preferred as per our requirement. We are using TO-202 standard package for the proposed design, LM35 can be configured as shown in the figure3.

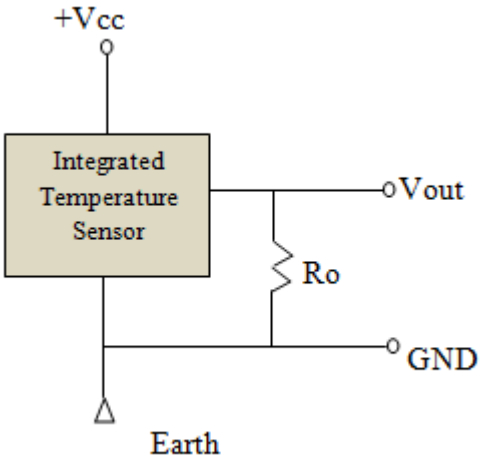

Figure 3: Configuration for Integrated Temperature Sensor

For configuration of the LM35 temperature sensor as given in the figure3, Vcc can range from 4V to 30V, but for convenience and compatibility it is preferred to use +Vcc as 5V. Value of Ro can be calculated as

$$Ro = +Vcc/10^{-6}$$

With, even, Ro=10K works better.

3. VLSI-CPLD DEVICE

It is **C**omplex **P**rogrammable **L**ogic **D**evice, Programmable Logic Array like structure. It has excellent features like In System Programmable along with Endurance of about 10,000 times of program/erase cycle. It has about 1600 usable gates which can be configured as per the hardware configuration, boundary scan support, and programmable power down mode, high drive 24mA outputs.

Basic elements are I/O blocks, Fast CONNECT switch matrix, function block, and In-system programming module.

I/O Blocks:

An I/O block is composed of input buffer, output buffer, multiplexer for the output control and grounding control and so on. Multiplexer for the output control (OE MUX) controls an output enable or stop. It is controlled by the signal from the macrocell or the signal of the GTS (Global Three-State control) pin. It can always make output '1' or '0', too. There are four GTS in XC95216 and XC95288 and in case of the other device, they are two.

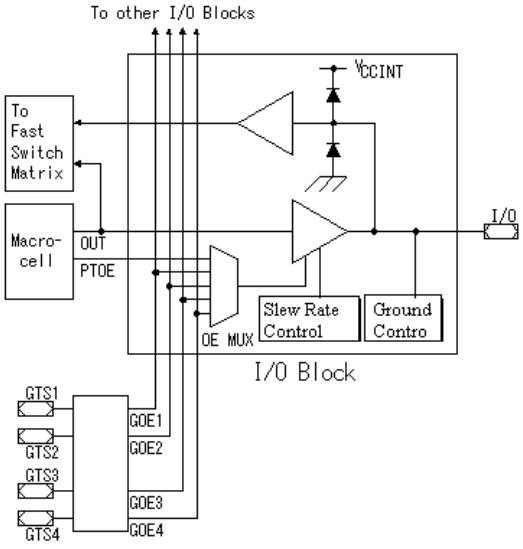

Figure 4: I/O Block

A slew rate control is the one to make the rising and the falling of the output pulse smooth. It is used when suppressing the occurrence of the noise. A grounding control is used when making input/output pin (I/O) an earth terminal. In case of the circuit where much noise occurs, it isn't sometimes possible to do noise reducing by the standard earth terminal. At the actual circuit, a pull-up resistor is more connected with the input/output pin. This circuit makes an input/output pin '1' condition compulsorily during programming of CPLD to make an influence by the condition of the I/O pin little. This circuit is detached in usual operation. Each input/output pin can handle a 24-mA current.

Fast Connect Switch Matrix:

Fast Connect Switch Matrix controls the input signals to the Function Block. All the signals from the input-output port and the signals of the Function Block are connected with Fast Connect Switch Matrix. The signals which are specified by the program out of these signals are applied to the Function Block. The output signals from the Function Block are applied to the Function Block through the wired AND buffer. This provides additional logic capability and increases the effective logic fan-in of the destination Function Block without any additional timing delay. It is automatically invoked by the development software where applicable.

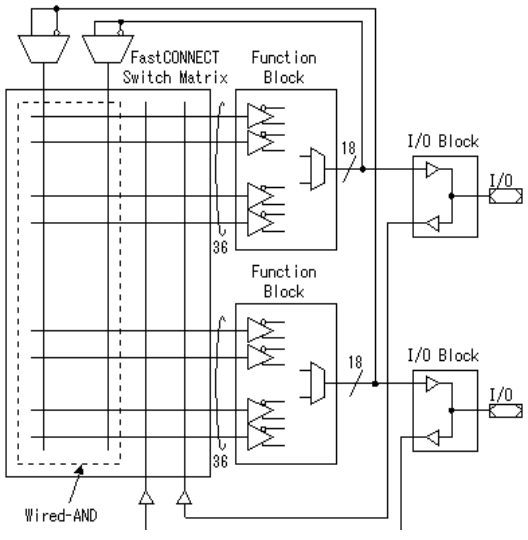

Figure 5: Fast Connect Switch

Function Block:

Function block is composed of the programmable AND array, product term allocator and macrocell. 36 pieces of signals inputted to the Function Block are divided into the true and complement signals by the programmable AND array and become 72 kinds of signals. In Product Term Allocator, it applies the signal with combination of them to the macrocell. A macrocell is composed of one D/T type flip-flop. The signals of set/reset/ clock to this flip-flop are supplied by the Product Term Allocator. The output of the logic circuit can be connected with the pin without using a flip-flop, too. There are 18 independent macrocells in one Function Block. There are 18 pieces of output in the Function Block and they are connected with Fast CONNECT Switch Matrix and I/O blocks. Also, the set/reset signal (GSR: Global Set/ Reset) and the clock signal (GCK: Global Clocks) are inputted to the Function Block and are used for the condition of the operation of the flip-flop according to need. PTOE (Product Term Output Enable) signal is output to I/O block from Product Term Allocator.

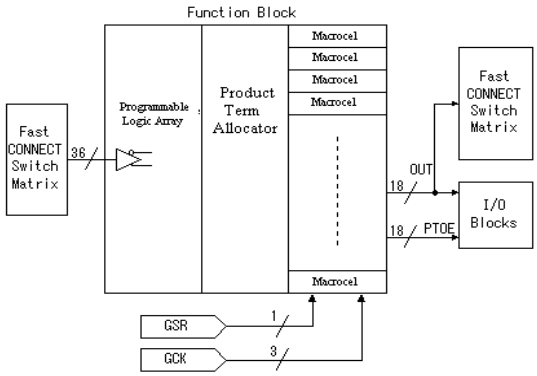

Figure 6: Function Block

The number of the Function Blocks depends on the device. As for XC9536, 2 blocks are mounted, as for XC9572, 4 blocks are mounted and as for XC95108, 6 blocks are mounted. It isn't sometimes possible to use all macrocells by the limitation on the number of the pins. For details, confirm pin diagrams. There are few cases which connect all macrocells with the pin actually. Generally, there are macrocells to use only in the logic inside.

In-System Programming Module:

XC9500 devices are programmed In-System via a standard 4-pin JTAG protocol. The devices fully support IEEE 1149.1 boundary-scan. Because it is equipped with the pin for independent JTAG, the program can be changed as it mounted CPLD on the printed board. While programming, all input ports in the I/O block are set to the 'H' level the wires to use in JTAG are the following four. Each use is shown below.

- ***TMS (Test Mode Select):*** This signal is decode by TAP controller to control test operations.
- ***TCK (Test Clock):*** This clock drives the test logic for all devices on boundary-scan chain.

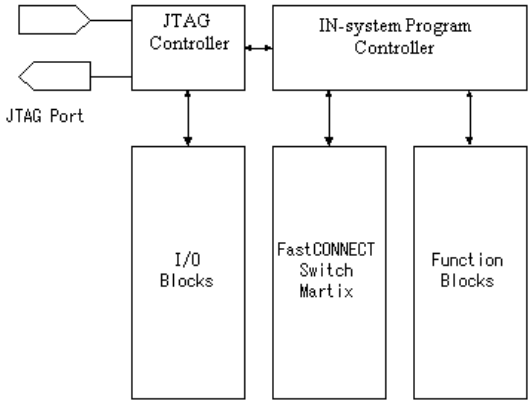

Figure 7: In-system Controller

- ***TDO (Test Read Data):*** Read back data from the target system is read at this pin.
- ***TDI (Test Data In):*** This signal is used to transmit serial test instructions and data.

Serial Data Controller:

For monitoring of the data over the computer based system, serial data transmission is best solution. Usually data communication can be bifurcated as single ended and differential. Out of which RS232 i.e. single ended data transmission is used. It provides full duplex communication protocol.

RS232 signals are represented by voltage levels with respect to system logic ground. The idle state has signal level negative with respect to the system logic ground and active state has signal level positive with respect to the system logic ground. It also supports numerous handshaking signals. Figure8 demonstrates example of transmission of asci value corresponding to "A".

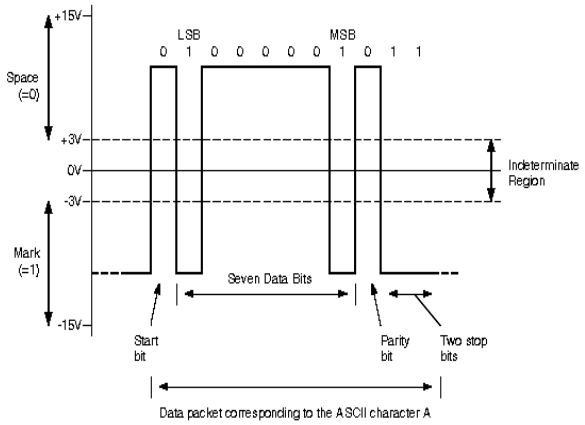

Figure 8: Serial Data Transmission

While transmission of data towards computer, first start bit is transmitted this initializes the reception of data at the receiver computer from next clock pulse. From next clock pulse actual data bits are transmitted, with MSB being first and LSB last bit. Transmission of parity bit is optional and finally the stop bit is transmitted which terminates the transmission of one byte.

4. CONCLUSION

Through this paper, a novel concept of power conversion from radio frequencies and noise signal from atmosphere into usable electrical power is demonstrated. The proposed concept uses fundamentals of energy scavenging, that collect the radio noise present in radio frequencies and from different other sources and converts it to usable power. Modern low power devices are used in the design so as to generated maximum usable power. For demonstration of strength of Ambient Power Source application of Data Acquisition is realized using low power VLSI – CPLD device which monitor the temperature of the atmosphere and displays the data on controlling computer using serial communication protocol.

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