# Design of Virtex-6 FPGA based Data Concentrator Card

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***Abstract*— A Data Concentrator for an avionics network, comprises of input/output interface (I/O) for connecting one or more input/output devices and remote processor. The Data Concentrator Units (DCUs) collect discrete inputs, analog signals, and digital data from sensors and equipment throughout the aircraft, then convert them to digital format for streaming over the data bus. The DCU is interfaced to the other systems by way of the aircraft digital data bus and is usually the data hub for most of the avionics equipment. This paper deals with the design of Virtex-6 FPGA (Field Programmable Gate Array) based Data concentrator card. Since it is based on FPGA the Data Concentrator is flexible, reconfigurable and high performance device. The FPGA can be programmed to the required functionality & only the minimum information will be passed on to the computer, thus reducing the load on the computer. The Schematic design is carried out using OrCAD tool.**

***Index Terms*— ARINC-429, Data Concentrator, DB9 Connector, OrCAD, Virtex-6 FPGA.**

## I. INTRODUCTION

The Integrated Vehicle Health Management (IVHM) system is to develop validated tools, technologies, and techniques for automated detection, diagnosis and prognosis that enable mitigation of adverse events during flight. Adverse events include those that arise from system, subsystem, or component faults or failures due to damage, degradation, or environmental hazards that occur during flight [1]. The aim of a Health Monitoring system is to detect and diagnose initiation of any defect, to analyze its effects and to trigger maintenance workflows in order to maintain safety of the aircraft. This is done by capturing data by a network of sensors and analyzing the data using life prediction algorithms implemented on highly evolved software systems [2].

A Remote Data Concentrator (RDC) for an avionics network, the RDC comprising an input/output interface (I/O) for connection to one or more input/output devices, and a network interface for connection to a remote processor, wherein the RDC is operable to provide communication between the input/output device(s) and the remote processor, and the RDC further comprises a set of instructions for autonomously driving an output device connected to the I/O.

The Data Concentrator Units (DCUs) collect discrete inputs, analog signals, and digital data from sensors and equipment throughout the aircraft, then convert them to digital format for streaming over the data bus [3]. In aerospace, DCUs can be used to upgrade an aircraft's cockpit system to a modern glass cockpit. DCUs can also control and monitor the health of multiple systems. A DCU can simplify aircraft system design and reduce weight. These products are compatible with a wide range of digital communication protocols including Ethernet; MIL-STD - 1553; EIA/TIA-232, -422 and -485; AFDX/ARINC -664; ARINC 429; USB 2.0; and Ethernet.

The parallelism, speed and I/O flexibility provided by today's Field Programmable Gate Arrays (FPGAs) make it possible for system engineers to replace multiple processor boards with a single FPGA COTS board. The FPGAs are configured to accommodate the complete digital systems with million's of equivalent gates in its reconfiguration fabric alone [4]. For the defence and aerospace market, where high performance frequently must be traded off with power and size/weight restrictions, these FPGA boards offer the best of both worlds: high performance in a single slot. One of the prime advantages of


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today's FPGAs is the balance they provide between processing and I/O. This balanced approach makes FPGAs very efficient at simultaneously processing several high-speed, parallel data streams.

In the proposed work Virtex-6 FPGA is used for the Data concentrator card. So it is flexible, reconfigurable and high performance device.

## II. DESCRIPTION

Data concentrator units (DCUs) for avionics network collect discrete inputs, analog signals, and digital data from sensors and equipment throughout the aircraft, then convert them to digital format. In today's market the available Data concentrator units (DCUs) are processor based that receives a diverse assortment of discrete, analog and digital inputs to process and format them into other common digital data formats for various aircraft systems' consumption. The DCU design can accommodate a slew of digital communication protocols including EIA/TIA-232, -422, -485, ARINC 429, USB 2.0, ARINC-664, MIL-STD-1553, CAN bus and Ethernet [5]. The DCU commonly serves as the data hub for most of the avionics equipment of an aircraft. It interfaces to other systems through ARINC-429 and Ethernet data buses. The DCU can be configured to operate in a master-slave control mode where inputs and outputs can be coupled for active-active or active inactive control. This configuration can be used to reduce the complexity of the aircraft system design, interface I/Os and overall weight reduction of the aircraft/DCU system.

In the proposed work, Virtex-6 FPGA based Data concentrator card is designed using OrCAD. Main application of designing FPGA based data concentrator card is to reduce the load on the main computer which is monitoring the health of the aircraft. And also FPGA based Data Concentrator card is flexible, reconfigurable and high performance device. It performs processing operations along with the basic operations like transfer of data.

The Virtex®-6 FPGA family is the high-performance silicon foundation for Targeted Design Platforms [6]. Consuming 50% lower power and delivering 20% lower cost than the previous generation, the new family is built with the right mix of programmability, integrated blocks for DSP, memory, and connectivity support - including high-speed transceiver capabilities - to satisfy the insatiable demand for higher bandwidth and higher performance.

Virtex-6 FPGA is compatible with ARINC 429 digital communication protocol. ARINC 429 is the most commonly used data bus for commercial and transport aircraft. ARINC 429 is a two-wire, point-to-point data bus that is application-specific for commercial and transport aircraft. The connection wires are twisted pairs. Words are 32 bits in length and most messages consist of a single data word. The specification defines the electrical standard and data characteristics and protocols [8]. ARINC-429 employs unidirectional transmission of 32 bit words over two wire twisted pairs using bipolar RZ format [9].

Proposed design is carried out in OrCAD tool. OrCAD is a suite of tools from Cadence Company for the design and layout of printed circuit boards (PCBs). OrCAD offers a total solution for core design tasks: schematic and VHDL- based design entry. FPGA design synthesis; digital, analog and mixed-signals emulation; and printed circuit board layout.

## III. IMPLEMENTATION

The work deals with the design of Virtex-6 FPGA based Data concentrator card. Fig 1 shows the block diagram of the design.

Virtex-6 FPGA based Data Concentrator is flexible, reconfigurable and high performance device. It accepts the inputs from various aircraft subsystems. The FPGA can be programmed to the required functionality & only the minimum information will be passed on to the computer, thus reducing the load on the computer. Output from the FPGA is given to the computer via DB9 connector in ARINC-429 format. The Power section generates various voltages required for different components. Other interfaces like SPROM and JTAG are used for configuration and programming. The clocking system synchronizes the movement and processing of data through the different modules in the system. DB9 connector is used for serial communication and for serial interface with ARINC-429. MAX3223 serves as an interface between DB9 connector and the FPGA. Test points and LED's are used in testing and debugging mechanisms.


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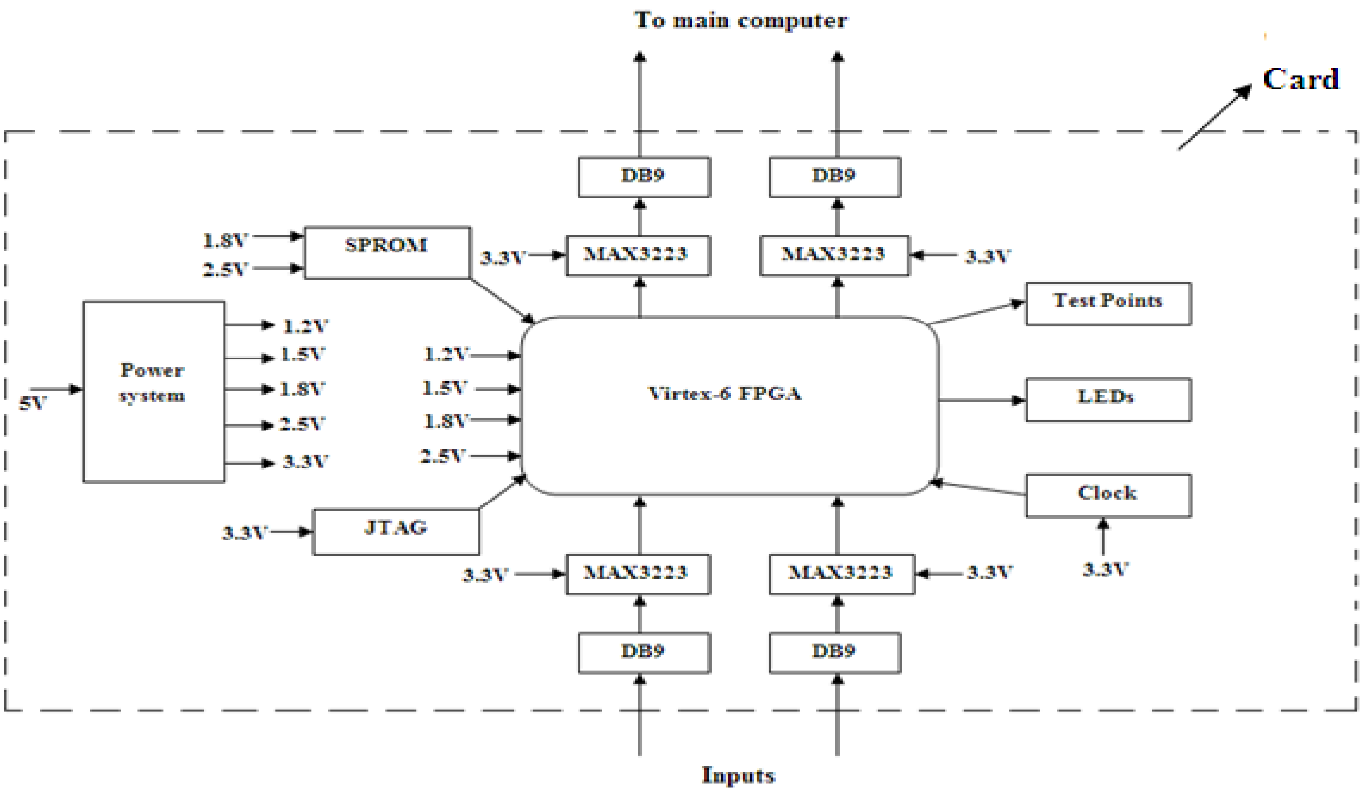


**Fig 1.** Block diagram of FPGA based Data Concentrator card

Virtex-6 FPGA is the high performance device and has low static and dynamic power dissipation. Advanced process, improved routing, faster pipelining features results in faster logic. And also Virtex-6 FPGA is compatible with ARINC 429 digital communication protocol. At up to 50% lower power and 20% lower cost than previous generations, the new Virtex®-6 FPGA Family delivers the right mix of flexibility, hard intellectual property (IP) cores, transceiver capabilities, and development tool support that enables Xilinx customers to meet the demands of markets with evolving standards and stringent performance requirements in the pursuit of higher bandwidth. For volume production, EasyPath™ FPGAs reduce cost for volume production with no risk of conversion and no hidden costs [7]. Built on a 40nm process using third-generation Xilinx ASMBL™ architecture, the Virtex-6 FPGA family is supported by a new generation of development tools and a vast library of IP to ensure productive development and efficient design migration from previous generations. Providing higher performance and lower power consumption compared to competitive FPGA offerings, the new devices operate on a 1.0V core voltage with an available 0.9V low-power option.

Power section is an essential component in the design. Power module provides high-performance step-down conversion from a 5V input bus voltage. It takes 5V input supply and generates different voltages like 1.2V, 1.5V, 1.8V, 2.5V, 3.3V etc needed for different components in the design. Virtex-6 FPGA requires different voltages like 1.2V, 1.5V, 1.8V, 2.5V and other peripherals require 1.8V, 3.3V. Hence the power regulator generates different voltages by changing the value of resistor.

Serial Programmable Read Only Memory (SPROM) is a configuration and storage device and is specially optimized for high-performance FPGA configuration. Serial or parallel FPGA configuration interface, multiple design revisions for configuration, built-in data de-compressor, convenient built-in power-up sequencing for FPGA data integrity are the features of SPROM.

Joint Test Action Group (JTAG) used for programming, debug, probing port and boundary scan testing. Test points and LED's are used in testing and debugging mechanisms.


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The clocking system synchronizes the movement and processing of data through the different modules in the system. The first step in any FPGA design is to decide what clock speed is needed within the FPGA. The fastest clock in the design will determine the clock rate that the FPGA must be able to handle. The maximum clock rate is determined by the propagation time. Suitable crystal oscillator is used to generate the clock frequency. Clock frequency of 100 MHz is used in this design.

The DB9 connector is mainly used for serial connections, allowing for the asynchronous transmission of data as provided by RS-232 standard. DB9 connectors are used for the ARINC-429 serial interface standard, which determined the function of all nine pins as a standard. MAX3223 serves as an interface between DB9 connector and FPGA. The MAX3223 consists of two line drivers, two line receivers, and a dual charge-pump circuit with ±15-kV ESD protection pin to pin (serial-port connection pins, including GND). The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector.

Inputs from different aircraft subsystems are given to FPGA via DB9 connector. FPGA with other peripheral parts will do the required operations and processing operations with high performance. Output from the FPGA is given to the computer via DB9 connector which is monitoring the health of the aircraft.

Schematic design is done using OrCAD tool, and the Design Rules Check (DRC) is done for any error in the schematic design.

## IV. CONCLUSION

Virtex-6 FPGA based Data Concentrator is flexible, reconfigurable and high performance device. It performs processing operations along with the basic operations like transfer of data. The Data Concentrator card accepts discrete, digital, and analog inputs from various aircraft subsystems. Main application of designing FPGA based data concentrator card is to reduce the load on the main computer which is monitoring the health of aircraft. FPGA based data concentrator card used in IVHM systems sends the data from one system to other with less complexity, greater performance. It also helps in simplifying aircraft avionics system design and also reduces the weight.

## V. FUTURE WORK

Advanced FPGAs with inbuilt Aircraft digital data bus cores can be used in designing the data concentrator card. And also the design can be extended for more number of channels to increase data reception and transmission.

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