Low Cost Labview Based Sensor Simulation

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Abstract-A new method for sensor simulation using LabVIEW software is described, which utilizes LabVIEW mathematical functional blocks to perform sensor transfer function depending on type of sensor. The Resolver is simulated with LabVIEW software along with an FPGA card. Resolver is often used for measuring the angular position and speed of the motor or shafts, where in the shaft angle of the resolver is simulated by generating Sine and Cosine feedback signals.

Index Terms-Sensor Simulation, Resolver, FPGA (Field Programmable Gate Array), Angular Position, PXI System, ADC, DAC

1. INTRODUCTION

In this fast moving world, the technology plays a vital role. For the growth of technology, embedded control devices are essential. With the increase in embedded control devices, the demand of testing becomes a necessity. This has led to the production of automatic test systems. Automatic test systems can calculate the measurement functionality and performance by simulating realistic signals and validating the expected result[1] [2].

Simulation of sensor is done by providing sensor signals to the input of unit under test (UUT) or device under test (DUT) and examining how the device responds in different working condition [3][4]. The advantage of sensor simulation is that the ability to test fault conditions that will somewhat be harming or hazardous. So that the system components can be implemented with corrective changes and tested without destroying the devices [5]. In this sensor simulation of resolver is described. The Resolver is simulated with LabVIEW software along with an FPGA card[6]. Resolver is an analog electrical transformer used for measuring the angular position and speed of the motor or shafts[7] [8], where in the shaft angle of the resolver is simulated by generating Sine and Cosine feedback signals [9] [10] [11]. Compared to other position and speed sensors, resolvers has high speed and resolution and capable of handling harsh operating conditions [12]. By taking the advantage of FPGA, developers will be able to make complex hardware that can conveniently reconfigure [13].

2. LITERATURE SURVEY

A new method for converting the sine/cosine signals into the angular position by comparing the amplitudes of the resolver signals with the excitation signal is proposed as in [14]. In [15], the creation of a full resolver system simulation for a hybrid electric vehicle electric drive application is done in MATLAB SIMULINK is a complex task.Inverse tangent method is used to get the angular position of the rotor based on resolver to digital converter [3].When speed, efficiency and performance becomes a necessity, software method alone will no longer be effective. In order to avoid the hardware problem we used FPGA. As a result sensor simulation is implemented by utilizing the advantageof FPGA hardware.

3. OBJECTIVES

- To design and develop a low cost LabVIEW based sensor simulation
- To design and implement a resolver simulator on a FPGA board

4. DETAILED PROBLEM DEFINITION

Resolver simulator plays a major role in industrial automation for the testing of different equipment's. Implementation of low cost sensor simulation is a challenging task. The resolver simulators currently available in the market are quite expensive which led to the development of simulators at relatively lower cost. So, in this our goal is to develop a low cost method for the simulation of resolver with LabVIEW software along with a FPGA card.

5. SOLUTION METHODOLOGY

In this project, we developed a system in order to fulfil our objectives. FPGA is the backbone of our project. We have used LabVIEW 2013 and NI

PXI-7841R module along with NI PXI 1033 chassis with integrated controller.

The resolver simulation is realized in LABVIEW software using FPGA card with analog input/output to digitize the resolver signals. The angular position or speed is given as the user input to the simulator. The resolver shaft position is in degrees, which will be used for trigonometric functions which are multiplied by the excitation signal to generate Sine and Cosine output.

We have selected the NI PXI FPGA modules by considering the accuracy, resolution, sampling rate and above all, the cost.

6. DESIGN AND MODELLING

This section outlines, about the design and modelling of sensor simulation.

Our main concern in designing is the selection of the right FPGA hardware. NI offers a wide variety of FPGA hardware modules with programmable FPGA along with analog and digital input/output; among them we have to select the suited one. In NI the FPGA hardware spread out into different sections, i) Monitoring and Control, ii) Test and measurement iii) Machine Vision and Image Acquisition. In Test and Measurement section we found out the NI R Series Multifunction RIO can be used for the sensor simulation.

The input/output to and from the LabVIEW is done through ADC and DAC. So we have to select the FPGA card module with an inbuilt ADC&DAC. NI R series multifunction RIO provides 12-bit, 14-bit, 16-bit resolution ADC/DAC. We go for 16-bit resolution because a 16-bit ADC can represent 65536 voltage levels. Hence, for each change in angle (degree) it will be able to produce more accurate output.

Next challenge is about the sampling rate. If the excitation signal has maximum frequency of 12 kHz, the sampling rate should be 10 or 12 times the maximum frequency then it will become 120 kHz. According to our requirement we can choose the 220 kHz, 750 kHz sampling rate FPGA module. For our design we needed only 220 kHz sampling rate.

As a result, we decide to take NI PXI 7841-R. The FPGA hardware platform comprises of chassis and controller besides multifunction RIO PXI 7841-R. To reduce cost we picked the chassis with integrated controller, NI PXI 1033.

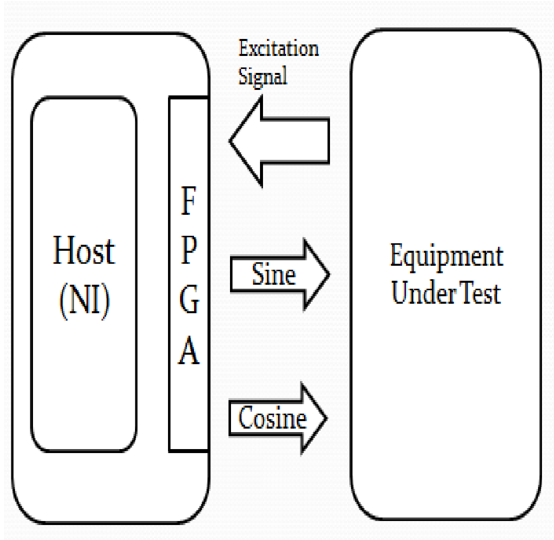

Fig. 1 Block Diagram of LabVIEW based sensor simulation

Figure.1 shows the design of sensor simulation based on LabVIEW software. Block diagram consist of equipment under test, FPGA card and Host PC. In this the excitation signal for the FPGA module is captured from the equipment under test through the ADC. Sensor simulator generates Sine/Cosine outputs of resolver based on the excitation signal from equipment under test and the simulated angular position in degrees or speed in rpm. The simulators output is fed back to device under test through 2 DAC's.

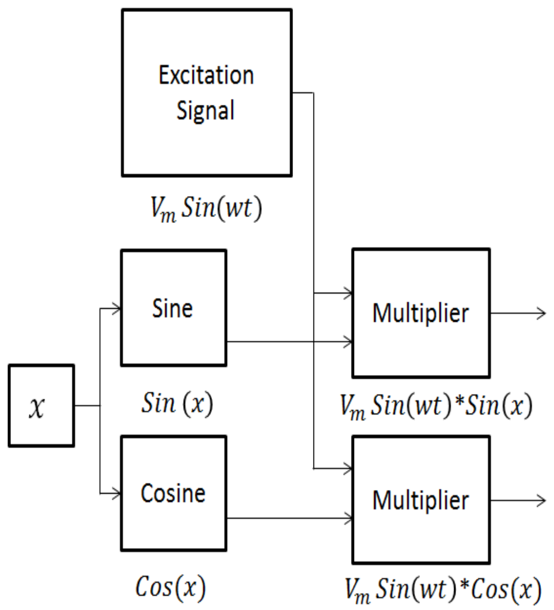

Fig.2 Code Block Diagram

Block diagram consist of excitation signal, Sine /cosine and Multipliers. Rotor angular position is given as the input (Angle (x)) which is fed to the sine /cosine block which will produce corresponding sine/cosine terms to the multiplier. Another signal called excitation signal is provided to the multiplier, where the excitation signal and sine/cosine terms of angular position get multiplied.

7.IMPLEMENTATION

The proposed system is implemented with the help of LabVIEW and FPGA hardware module. The system comprises of LabVIEW 2013 software, FPGA hardware platform: NI PXI 7841-R, NI PXI 1033

7.1. LabVIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a development environment and capable of handling inputs, predict outcomes on the basis of graphical program and control outputs. LabVIEW offers a custom graphical user interface for data acquisition, instrumentation control and measurement.

7.2. PXI 7841-R

NI PXI 7841-R is a multifunction reconfigurable I/O (RIO) consist of a user programmable Virtex-5 LX30 FPGA chip and dedicated analog to digital converter (ADC). It has 8 analog inputs with a sampling rate of 220 kHz and 16-bit resolution.

7.3. PXI 1033

NI PXI 1033 is a 5-slot PXI chassis with integrated MXI-Express controller. It provides a 110MB/s sustained throughput.

8.RESULTS

This section deals with the simulation of resolver for different angles.

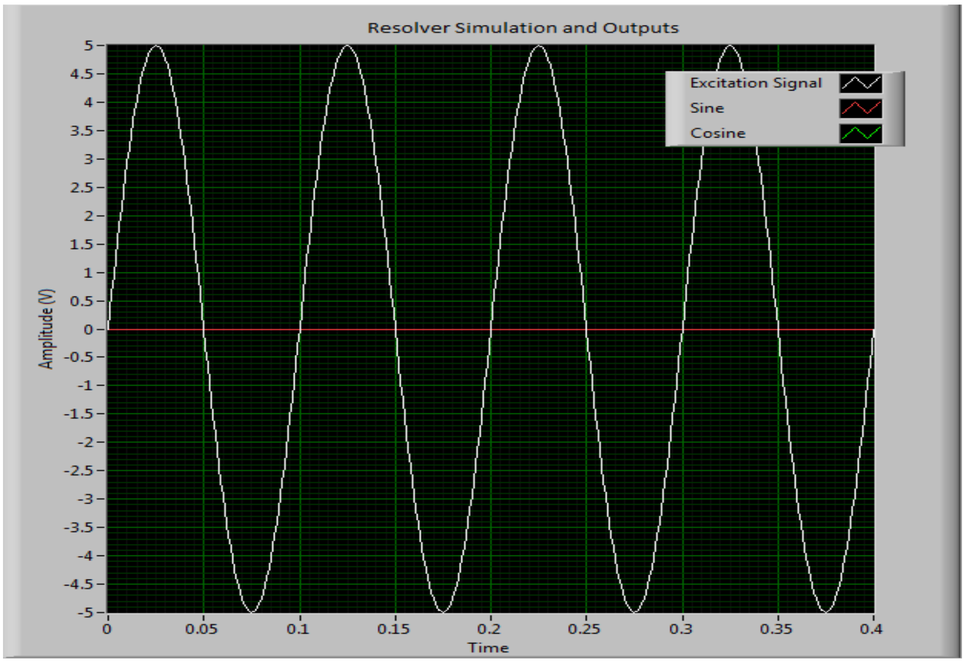

Fig. 3.1 $\theta = 0°$ (Zero degree)

Fig. 3.1 represents the resolver simulation at zero degree (0°) angular position. At zero degree, sine output will be zero so the simulated sine output will also be zero (red line) and the cosine output is one so the simulation cosine output will be same as the excitation signal (Excitation signal and Cosine signal are over overlapped).

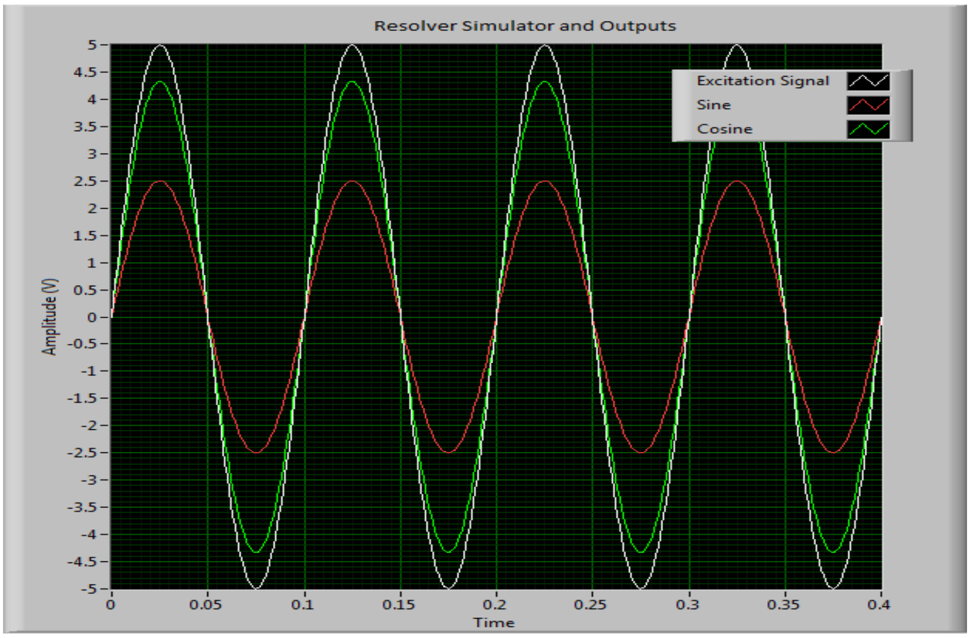

Fig. 3.2 $\theta = 30°$

Fig. 3.2 represents the resolver simulation at thirty degree (30°) angular position. At thirty degree, sine term will be 0.5 whereas cosine term will be 0.866 and when it multiplied with excitation signal, simulated cosine output (green) will be in higher position than the sine (red).

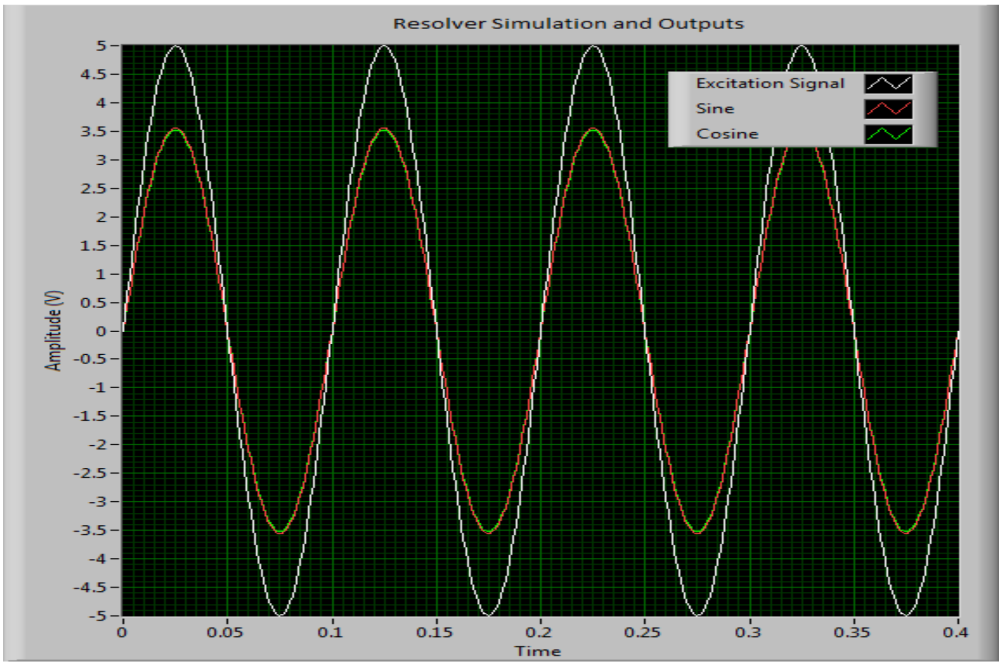

Fig. 3.3 $\theta = 45°$

Fig.3.3 represents the resolver simulation at forty five degree (45°) angular position. Sine and cosine output is same at this angle, sowhen multiplying with excitation signal also the simulated sine and cosine output won't change (red and green line overlapped).

9. CONCLUSION

The proposed system brings a clear idea in how the device responds in different working conditions by providing realistic signals. Sensor simulation allows the engineers to test fault conditions and implement the corrective changes without destroying the devices. By using the sensor simulation, the device under test can be directly given to the working of actual plant for final formation

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