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Firmware Functional Tester for household washing machine controller using LabVIEW

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Abstract - Verification is one of the basic steps in deciding whether the system that has been designed according to the specifications and well-defined requirements has satisfied the criterion for being precise and accurate. Increasing reliability standards and testing capabilities of the washing machine electronic control boards (ECB), and implementing an automatic testing system for embedded firmware validation to save time and resources. Firmware functional tester to configure and run the test scripts, select sensors and data acquisition channels, control the ECB via Bluetooth protocol and run test scripts to washing machine manufacturer to offer significant increase in number of functionality and features.

Key Words: *cRIO, Washing Machine, Reflective sensor, Thermocouple, LabVIEW Software.*

1. INTRODUCTION

This Document is based on developing automatic testing software for Washing machines to test their functionality to validate embedded firmware and to monitor data. Acquiring the speed of rotation and temperature values through reflective sensors and a thermocouple and calibrating in software and configuring the software based on the script to check functionality of washing machine controlling through software and communicating via Bluetooth interface. Testing makes a major role in today's field of technology, Automation testing before take into market will lead to grab the market and easily can able to attract the customers provided with good products. In this automatic testing of washing machine and logging obtained result with highlighting the not executed events. Software designed with good graphical user interface and improvement for future scope.

2. LITERATURE SURVEY

Literature survey gives the knowledge about the project by researching work done related to project or things used in their project and knowing about history and properties of all the works and objects.

Literature survey

History

Washing by hand required more man hand, to reduce man effort and process time first washing machine design was published in 1767 by Jacob Christian schaffer in Germany. British got a patent for rotating drum washer in 1782 and after few years later Edward Beetham sold numerous "patent washing mills" in 1790 and that were the first washing machine with enclosed containers or basins had grooved, fingers to help with the scrubbing and rubbing of cloth. Advanced one was come with rotative wooden drum design. Wooden drums were replaced by metal drums with open fire at the top or enclosed fire chamber, raising the water temperature for efficient washes.

Richard Lansdale of Pendleton patented compound rotary washing machine in 1862 and exhibited in London Exhibition. In 1937 domestic automatic washing machine by Bendrix Home Appliances patented in same year. Permanent connection to both hot and cold water supplies continuously. In, modern European machines have cold water connection and rely completely on internal electric heaters the water temperature.

US domestic washer production was stopped due the World War 2 in favor of manufacturing war material. However, numerous US appliance manufacturers were given permission to undertake the research and development of washers during the war years. In 1940 and later many manufactures introduced competing automatic machined.

Thomas Seebeck discovered the basic principle of Thermocouples in 1821 by connecting two wires of dissimilar metal joined at both end found out create a thermocouple loop. Loop produces a voltage based on difference in temperature between two ends in which one end temperature should be known.

Washing Machine Testing

Washing machine tested in the same way as we use, detecting and eliminating the problems in the product.

Testing like temperature, humidity, water pressure and how well cloth will clean. To stay in field and to grab market by making good product that done through testing because, china country produces at the rate of 10 than other country with less time span of production and with less price but they won't prefer testing most but more problem will arise. Customer satisfaction plays a major role in field for attraction. As in older days they were testing manually with analogue sensors and logging continuously on paper, which will be having less accuracy and time consuming. Both the things matter more in this competitive field.

Navdeepti Gaur explaining the working of automated washing machine; there are three states of working washing, rinsing, drying. Working of washing is fully controlled by controller and in washing state controller check the sensor data to know the water and detergent level, door is open/closed, load in the machine then start washing by opening water valve and closing drain valve. In washing state drum will rotate in clockwise or in anti-clock wise cloth will get centrifugal force to wash. Rinsing state will start after completion of washing state check the door, water availability, water valve and drain valve will be opened to rinse the cloths and last will be drying stage check the door and start spinning for an amount of time with drain valve is open and water valve is close, after completion beep sound will arises.

Chien-Lung Cheng explains about Automation testing DC motor for portable washing machine using LabVIEW was the paper published in 2008: Testing the temperature, transient current and steady state currents are measured to check the quality of motor. Hall sensor is used to measure the current and it is non-contact. Hall sensor used to measure magnetic field and its variation and non-contact temperature meter is used to measure the temperature and fed into DAQ (Data Acquisition) which will digitize the analogue signal and recorded analysed though LabVIEW.

3. HARDWARE DESIGN

BLOCK DIAGRAM

Major building blocks of this project are

- cRIO used as a controller.
- Washing machine is a SUT (System Under Test).
- NI modules to measure high quality with measurement specific.
- Thermocouple to sense Temperature inside the SUT.

Reflective sensor to detect direction and speed of motor

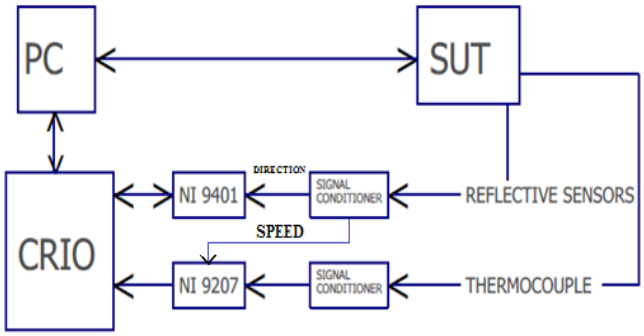


Fig1: Block diagram

cRIO 9067(Compact-RIO Controller)

The cRIO-9067 is an embedded controller ideal for advanced controller and monitoring application. This software-designed controller features an FPGA and a real-time processor running the NI Linux Real-Time OS which gives you access to the Linux community. This rugged, fanless controller offers a variety of connectivity ports, including two Gigabit Ethernets, one USB device, and one serial.

Features of cRIO-9067

- High speed 667MHz Dual-Core CPU.
- Volatile memory (DRAM) of 512MB.
- Nonvolatile memory 1 GB for storage.
- Xilinx Zynq _7020 FPGA.
- 8 _ Slot for c-series modules.

LabVIEW FPGA extends LabVIEW graphical development to FPGA-reconfigurable silicon on NI hardware. With LabVIEW FPGA, create custom I/O measurements and control hardware without low-level hardware description languages or board-level design.

LabVIEW Real Time Consist of RTOS which can be programmed to meat hard real-time program and once programmed and deployed then it will run continuously without any user interface.

LabVIEW is a graphical programming environment used by scientists, engineers used for data acquisition, analysis and control on variety of operating system and is a user defined.

NI 9401

The National Instruments NI 9401 8-Channel Bidirectional Digital I/O Module is an 8-channel, 100 ns bidirectional digital input module for any NI Compact-DAQ or Compact-RIO chassis. The module can configure the direction of the digital lines on the NI 9401 for input or output by nibble (4

bits). Each channel is compatible with 5 V/TTL signals and features 1,000 Vrms transient isolation between the I/O channels and the backplane.

NI 9207

The NI-9207 is a combination voltage and current input module designed with industrial systems in mind. It features eight current and eight voltage input channels, with built-in noise rejection. Speed of acquisition up to 500S/s.

K-TYPE THERMOCOUPLE

A thermocouple is an electrical device consists of two dissimilar conductor forming electrical junctions at differing temperature. A thermocouple produces a temperature dependent voltage because of the thermoelectric effect; this voltage can be interpreted to measure temperature. Thermocouples are self-powered and no form of external excitation required. Type K Thermocouple (Nickel-Chromium / Nickel-Alumel) is the most common type of thermocouple. It's inexpensive, accurate, reliable, and has a wide temperature range. The type K is commonly found in nuclear applications because of its relative radiation hardness.

REFLECTION SENSORS

Reflective sensor used to detect the direction of rotation and to count the pulses to detect speed, light will have emitted and sensed back based on reflective tapes (white color) placed on motor. Photoelectric sensor will detect the reflected light from Reflective tapes. Two Reflective sensors are placed to find the speed in different direction of rotation and four sensing elements over motor.

SIGNAL CONDITIONER

Signal conditioning is the manipulation of a signal in a way that prepares it for the next stage of processing. Temperature signal will be converted to voltage. Frequency of rotation will be converted into voltage to determine the speed of rotating shaft that will be fed into 9027 modules as a voltage input.

3. SOFTWARE DESIGN

Creating User Interface with SUT to control, analyze log the detail to test SUT.

USER LOGIN SCREEN

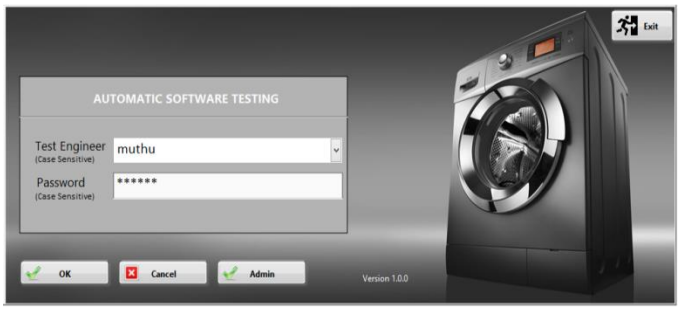


Fig2: User Login Screen

User login screen make limited users to enter into test handling and data management screens. Admin can enter into data management, configuration and scripting screens. Other users can only enter into test screen.

SELECTION SCREEN ADMINISTRATION MODE

Selection screen for admin to change any configuration, change the scripts used for test and also for data management.

Fig3: Selection Screen Administrator Mode

DATA MANGEMENT SCREEN

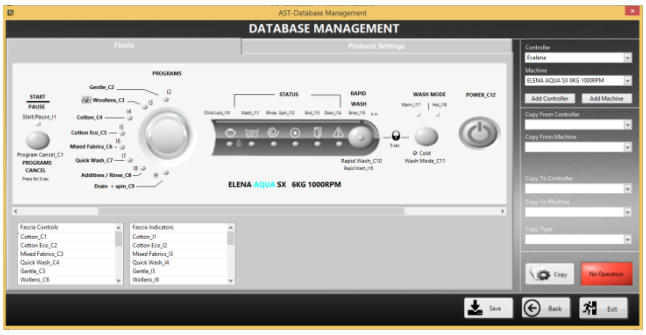


Fig4: Database Management Fascia screen

Controls and indicators of machines in controller can be managed, protocol settings for Bluetooth communication with SUT will be defined and also programming for LEDs can be managed.

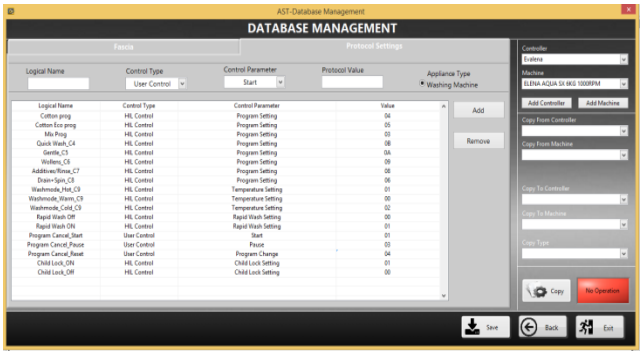


Fig5: Database Management Protocol Setting Screen

CONFIGURATION SCREEN

Add mapping to controls with database management, for DAQ communicating values defining the type of input type to calibrate and scaling to required data by adding inputs outputs range and Bluetooth communication mapping like type of connection, communication type, baud rate.

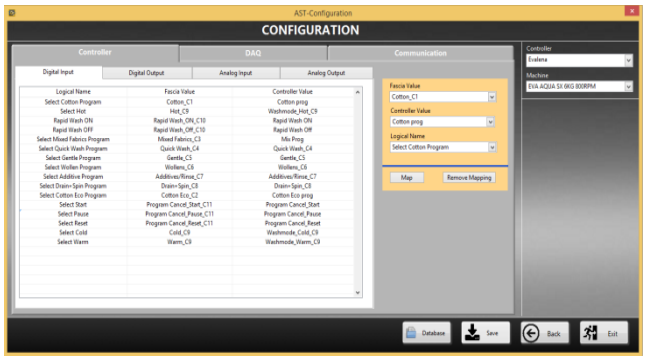


Fig6: Configuration screen

TEST SUITE SCREEN

Test scripts will be added to test the functionality of the machine, n number of scripts can be added and can edited in edit test script screen and also copy from one machine to other also easy.

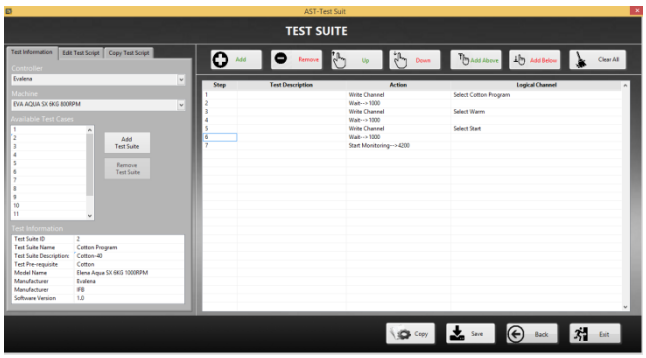


Fig7: Test suit screen

TEST SCREEN

Test screen to test functionality of SUT by selecting the controller, machine and test script want to test from the available test scripts, if all the event executed then it will log the details, if event or step not executed can be analyzed the problem with electronic control board. First it will check the primary safeties like communications are okay or not, door is closed etc.., Temperature, speed, water level and duty cycle are monitored plot to graph with time as reference, if Bluetooth communication last program will pauses or stores the result and can be continue from that position.

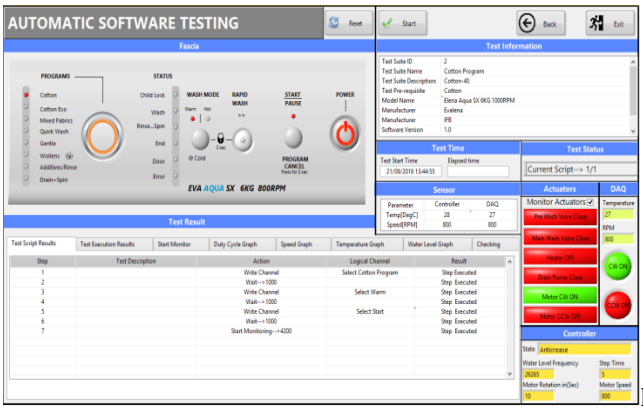


Fig 8: Main Test screen

TEST REPORT

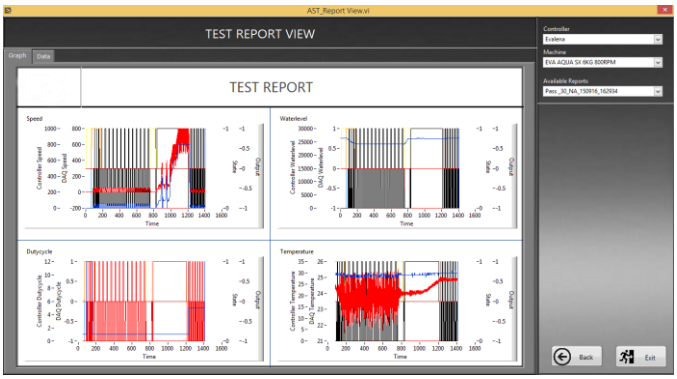
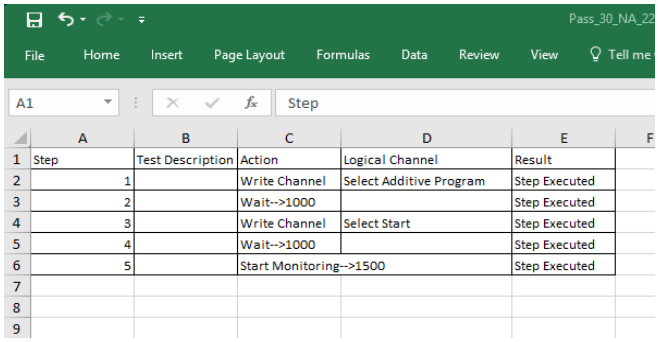


Fig 9: Test report screen analyses through graph.

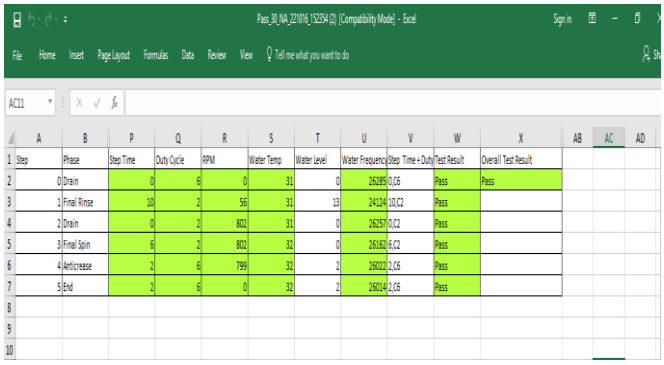
Test reports are analysed by selecting which control, which machine and the tested data, Temperature, water level, Duty cycle, speed. Checking the function executed and time taken for steps to execute.



	A	B	C	D	E
1	Step	Test Description	Action	Logical Channel	Result
2	1		Write Channel	Select Additive Program	Step Executed
3	2		Wait-->1000		Step Executed
4	3		Write Channel	Select Start	Step Executed
5	4		Wait-->1000		Step Executed
6	5		Start Monitoring-->1500		Step Executed

Fig 10: Test Script result

Test script added to check the controller function will be logged after test with steps executed for that program (cotton), if not means controllertreated as failed and will be reprogramming need to do and if all program executed then will be sent to mount in machine.



	Step	Phase	Step Time	Duty Cycle	RPM	Water Temp	Water Level	Water Frequency	Step Time + Duty	Test Result	Overall Test Result
2	0	Drain	0	6	0	31	0	26285	0,06	Pass	Pass
3	1	Final Rinse	10	2	56	31	13	24124	10,02	Pass	
4	2	Drain	0	2	802	31	0	26257	0,02	Pass	
5	3	Final Spin	6	2	802	32	0	26162	6,02	Pass	
6	4	Anticrease	2	6	799	32	2	26022	2,06	Pass	
7	5	End	2	6	0	32	2	26014	2,06	Pass	

Fig 11: Test result

Monitoring all the steps/phase for every second and checking the duty cycle at change in phase and step time, maximum speed and water level frequency in previous phase will exported to excel and compared with require result if it same marked as passed with green coloured background otherwise will marked as failed with red coloured background.

MANUAL MODE

Controlling washing machine to check the machine condition also manually control the function of working.

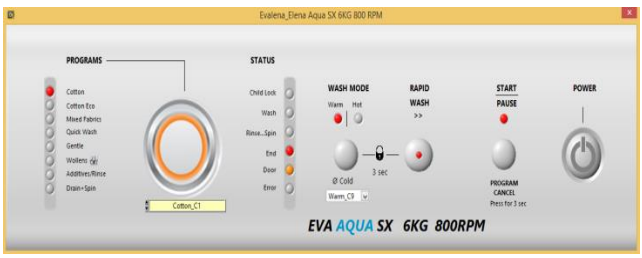


Fig11: Manual mode screen

CONCLUSION

The features automation reduces the man effort and gives the efficient, accurate result and effectiveness of handling controller to test the functionality will increase the stand time in market and attract the customers with valued satisfaction. LabVIEW software designed with good user interaction and compatible with NI components and also third-party devices making easier for testing and matching the obtained result with required result. Functionality checking plays one of the major role for the washing machine testing to make a good one. Storing all the result for every second and checking for the script and logging maximum speed of motor for every phase, delay, water level, temperature comparing with expected making easier for a test engineer to save time and to increase the accuracy of test.

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