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Test Automation of Protection and Control IED Manager using Robot Framework

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Abstract: Testing the PCM (Protection and Control IED Manager) application manually which internally configures IEDs (Intelligent Electronic Devices) is a time consuming process. In addition, manual testing is error-prone in few circumstances and hence automation is more useful. Robot Framework is an extensible tool and easy to understand as it includes keyword driven testing method. Robot Framework is easy to use with tabular syntax that enables creating test cases in uniform way. From the existing keywords in robot framework the high level keywords can be created that ensures the reusability and extensibility. Using basic library Application Programming Interface (API) for creating test cases in python is possible and output files are generated in XML format that provides integration for existing system. All this attributes ensures that Robot Framework is convenient for test automation of PCM application. Jenkins retrieves and updates the builds and run many test cases simultaneously for different IEDs. Therefore, continuous integration can be achieved easily.

Keywords: Protection and Control IED manager (PCM), Intelligent Electronic Device(IED), Test automation, Robot Framework

I. INTRODUCTION

Competition in the Information Technology field ends up with challenges so that the organizations and new companies need to make progress towards new thoughts and strategies to endure. Subsequently, the executives and creating groups need to deliver quality items that meet customer needs.

Building and keeping up quality programming is a testing undertaking since clients regularly change their prerequisites and tasks get bigger and increasingly muddled. Consequently, software testing is a necessary phase of current activities to guarantee the high quality product.

The Protection and Control IED Manager (PCM) device gives adaptable functionalities to the whole process of protection and control IED applications, at all voltage variations. This make simple to deal with the client along with equipment from application and configuration to signal matrix, event viewer, hardware configuration and disturbance reporting [1]. PCM is an application designed for communicating with IEDs over the TCP/IP via Local Area Network/Wide Area Network, or communicates directly through the communication port at the front of the IED. PCM application provides ability to perform read and write operations and sets data to IED with single command.

PCM application is used to control the IEDs in substation by trip command when voltage level varies. PCM application is compliant with IEC 61850 protocol where as IED is configured through this PCM application .

The IEC 61850-based data model in PCM is designed according to protection and control IEDs, that ensures easy integration between the PCM and IED [2].

PCM provides security to projects and information in previous version of PCM tool, that also provides compatibility. PCM scans and retrieves the required information from IED to generate the reports automatically. Alternatively, this reports can be sent to defined e-mail addresses automatically to facilitate fast actions.

II. INTELLIGENT ELECTRONIC DEVICE

A. IED

Intelligent Electronic Devices (IEDs) is the technical keyword used in electrical industry that describes controller based on microprocessor. This equipment may be circuit breaker, transformers and capacitor banks. In order to maintain desired levels, IEDs receives the signals from sensors and issues the commands that controls the IED for tripping down the breakers when IED sense voltage anomalies. These IEDs are designed with support of IEC61850 protocol standard for automation of substation and communication capability [3]. IEDs are the protection relays that includes different types such as Generator Protection Relay (REG), Motor Protection Relay (REM), Transformer Protection Relay (RET), Line Differential Protection Relay (RED) and Voltage Protection Relay (REU).

B. IED Basic Working

The input signal sent to the Analog-digital converter, converts the analog input to digital input. From there a part goes to protection unit and another part to measurement unit as shown in Figure 1. In measurement unit, it measures the voltage, current and so on. In protection unit, it continuously analyzes whether there is an increase in the voltage or current, or any abnormal sudden action that can be checked. If there is any abnormal condition like that, then the protection unit triggers the switch which activate and breakdown the breaker to provide the protection in IED's.

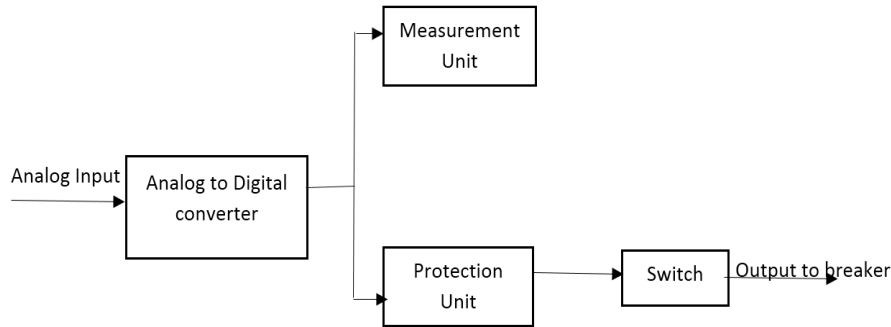


Figure 1. IED working flow chart

III. TEST AUTOMATION FOR PCM

There are various fundamental advantages from test automation like increase in quality of the product, reduce manual programming testing tasks and dispense with excess testing endeavors, produce progressively methodical repeatable programming tests, reduction of repetitive work and create increasingly steady testing outcomes, Greater consistency, executing more programming tests and accomplish a better testing coverage in an exceptionally constrained timetable and increments in the efficiency. Automation has gained popularity throughout the years and will acquire more popularity sooner rather than later. Suitable platform is chosen for testing PCM application that contains all the functionalities of IED through which IEDs can be configured with PCM application. Hence, IED is tested by automating the PCM application.

A. Choosing Open Source Framework

Robot Framework is chosen as framework for test automation. Robot Framework is flexible to use and can be used to test web applications, desktop application, mobile applications and RESTful and SOAP-based services. It requires less technical skills than a programming language-based frameworks, and this platform can also be used by the team member with less programming experience [4]. On other hand, Robot Framework includes keyword-based design, programmer with a high degree of technical skill can write keywords in the preferred language of their choice to test low level functions, and even do unit and integration testing [5].

B. Test Automation with Open Source Platform

The Robot Framework platform is chosen to automate PCM application. It is open source framework that is chosen for test automation. Further for end-to-end integrity testing Jenkins is used. As new build arrives Jenkins is used to automate software development process by updating the latest builds and test the PCM application to verify that latest build supports PCM application with continuous integration and facilitates continuous delivery [6].

C. Testing PCM application

IED is tested indirectly through PCM application which contains all the functions of IED. Initially the PCM application should be installed to configure with IED. PCM application connects to IED only when connectivity package corresponding to that particular IED is installed. IED includes different functions such as application configuration, signal matrix, hardware configuration, disturbance handling, parameter setting, event viewer and so on. All these function has to be automated with an open source framework.

IV. PROPOSED WORK

An open source platform is chosen for automation of PCM application. These PCM application is used for configuring the Protection and control IED manager. For testing purpose Robot Framework is used for test automation that should also include integration testing. Figure 2 shows the proposed work architecture for test automation using robot framework. Jenkins is used for continuous integration that provides end-to-end automation testing. As latest build arrives Jenkins retrieves, updates the builds and run many test cases simultaneously for different IEDs [7].

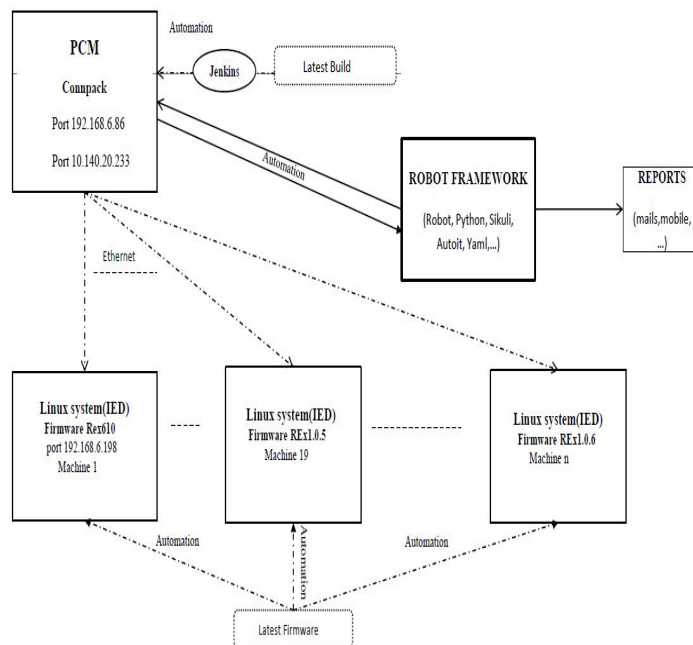


Figure 2. Proposed System

A. Robot Framework

After careful analysis, Robot Framework was found to satisfy all the requirements. Test automation is implemented in python that can be implemented on different major platforms [8]. Therefore, multiplatform requirement is fulfilled. Figure 3 represents the High level architecture of Robot Framework, the framework introduced by Nokia Networks meant to be used for free.

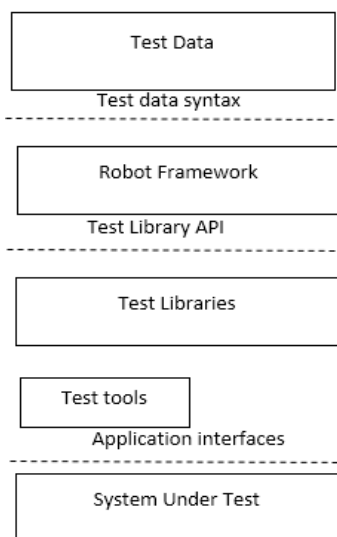


Figure 3. High level architecture

The test data is simple to edit in tabular format. Initially Robot Framework retrieves the written test data, executes corresponding test cases, generates the reports and creates detail logs. Libraries are available in Robot Framework which can be used with lower level test tools as drivers.

B. Installing Plugins

The 'pycharm community' is used to write test cases in Robot Framework. Initially when it is installed, the two plugins are installed such as Robot Framework Support and Intellibot. Robot Framework support is used for highlighting the syntax when the programmer writes the test case and provides the structural view of test case and keywords. Intellibot is also plugin that supports smart editing features to support Robot Framework.

C. Libraries

The required Libraries are installed such as Yaml, ExcellLibrary, Process, SikuliLibrary and AutoITLibrary. Figure 4 shows the installation of libraries, these libraries are installed through pip and set as interpreter with python path.

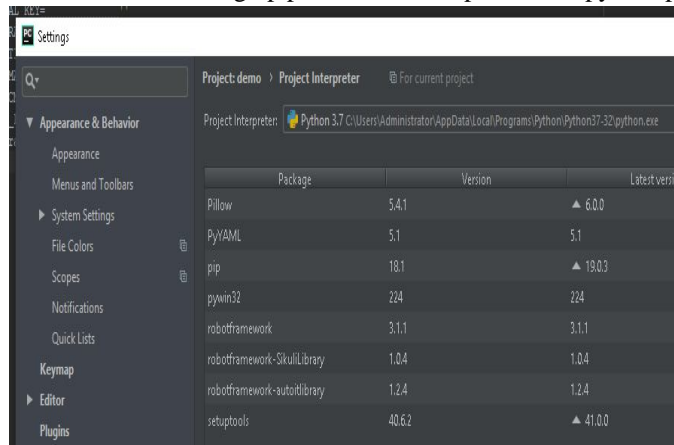


Figure 4. Libraries in Robot Framework

D. Sikuli Images

Sikuli Images are used for test automation in Robot Framework. The required images are captured using snipping tools or screenshot in sikulix-IDE and sikuli keywords are used in test cases to perform some action with captured images [9]. These images are stored in particular directory with “add image path” keyword and perform some action using sikuli library keywords. Figure 5 shows usage of sikuli keywords such as click, clickin, wait for image, etc. for test automation.

E. AutoIt tool

Figure 5 also depicts how AutoIt Libraries keywords are used such as minimize all window, maximize window, wait for active window, win activate, etc. Its functions can also be used for test automation of PCM application. AutoIt tool includes spying that helps in retrieving some data attributes and values which can be used with AutoIt keywords [9].

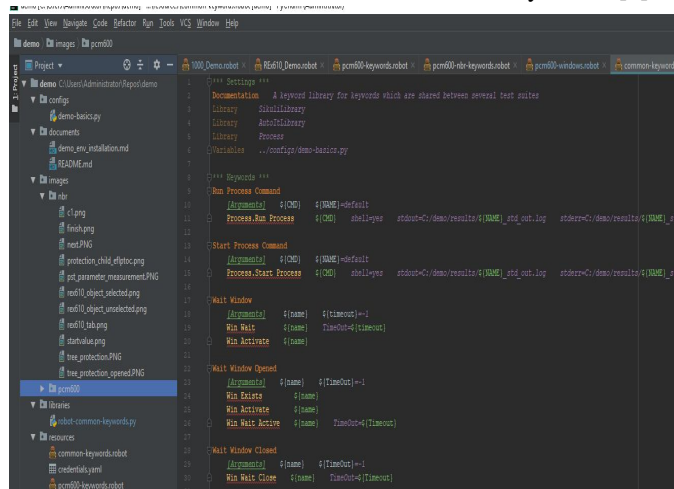


Figure 5. Usage of libraries in Robot Framework

F. Jenkins

After a code commit, a software is built and tested for continuous integration. In large projects the commits are for many times. Each of these commit code is built and tested. The code is built and tested as soon as developer develops the code. When the latest build is arrived, Jenkins deploys the source into the test server and notifies the deployment team. The latest builds are updated and test the compatibility of PCM application with latest builds. Jenkins allows to run number of test cases to different IEDs simultaneously there by providing continuous integration, automated builds and less test process time. The development cycle is faster and new features are more readily available to users.

G. Reports

After execution of testcases the reports are generated in HTML and alternatively the output file is generated in XML format which can be opened using any of the browser and can find successful or failure of test cases.

V. RESULT ANALYSIS

Robot Framework is a command line tool that is possible to execute test suite or some test cases directly from the command line so that execution is much easier to automate. The required test suite is executed through command line and after executing the test suite, HTML report is generated as shown in Figure 6 and background color represents whether the whole test suite is successfully executed or failed. If the critical test cases are passed successfully, the report will be marked as OK. The statistics that will be generated shows the number of test cases failed and specifies the details of the failed test cases.

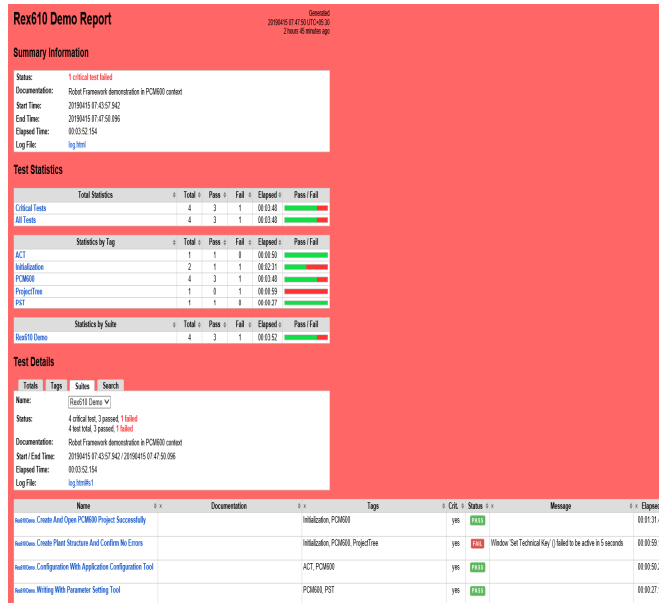


Figure 6. Test case report file

For further analysis, there is also detailed log generated as depicted in Figure 7 with all actions used in test cases and the detailed description of input and keyword output parameter along with marked action. Additionally, the keyword “Log” is used to write to log file. As log is generated in HTML format, it is convenient for report analysis. Robot Framework also generates XML output file which can be alternatively used.

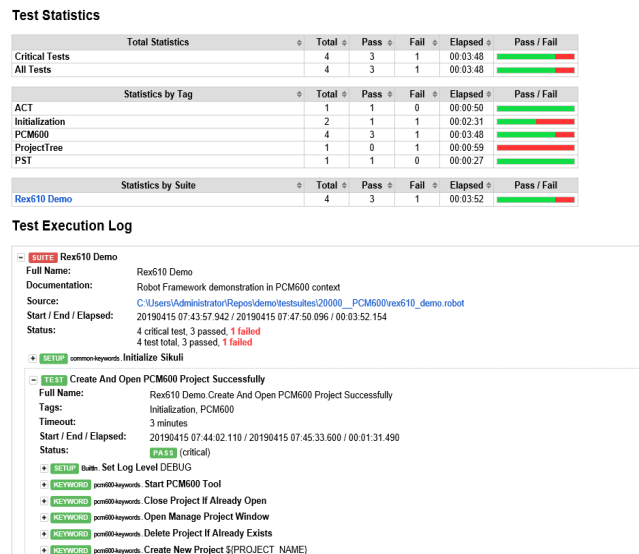


Figure 7. Test case log file

Jenkin plugins collect the results and publishes Robot Framework test results within Jenkins. The path should be set to indicate where the results should be located before executing the test cases in Jenkins. Figure 8 shows trendy graphs of test suite and test case details in Jenkins. It provides environmental variable expansion for builds in the paths. Wildcard supports the output files for parsing multiple Robot result files. Jenkins provides a graph with passed test over builds on project page marking the build failed, unstable or successful according to pass threshold given by the user. It provides the option of evaluating only critical tests against the pass thresholds. List-view-column in Jenkins is used to show overall passed or failed tests in project listing [14].

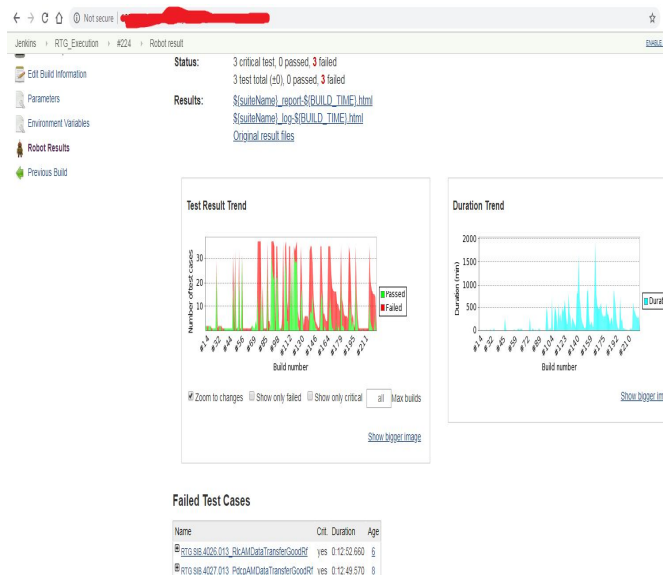


Figure 8. Graph generated in Jenkins

VI. BENEFITS OF TEST AUTOMATION

Manual testing takes longer time to test any of the operation with IED and hence to save time, the testing is automated that includes debugging method in faster way. Automation helps in reducing the expenses by finding the bugs in earlier stage and reduces the working hours to fix the raised problems [11-13]. There is no need to write the new scripts for each test, instead the existing scripts can be re-used for automation. Before the usage of Robot Framework, the testing was taking more time for executing the test cases with one person being busy in tracing. Whole process in Robot Framework takes only few hours, with only one batch command to run the test suite. Therefore, the person is not busy during test suite execution and can do other work. Hence, this is why the test automation using Robot Framework is beneficial as shown in below Table I.

Table I. Used Time Comparison

	Time used (in hours)	
	Manual	Automated
Test case of one test case	12:00	8:00
Execution of one test case	0:10	0:02
Check of one test case	0:05	0:01
Report generated after execution	2:00	0:01

VII. CONCLUSION

Benefits of using Robot Framework for automation of PCM application is creating the test case that follows work flow with verification of test case, actions and cleanup. It is an Open source framework where actual language can be used for keyword description, so that it is also easy for non-technical users to use basic library API that provides compatible tool for automation of PCM application. All process is automatically checked without manual interruption and reports are produced and published on web pages and hence saves time. Jenkins is introduced for updating new builds and executing many test cases for different IEDs simultaneously that provides continuous integration. Automation using Robot Framework offers more benefits like saving the cost and time. Hence, this highlights the features of Robot Framework.



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