

# TEST AUTOMATION FRAMEWORK FOR RTU

Poluri Pradeep Kumar, Ch.V.S.S.Sailaja, Pinjari Veneesh Basha

VASAVI COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING, HYDERABAD, INDIA

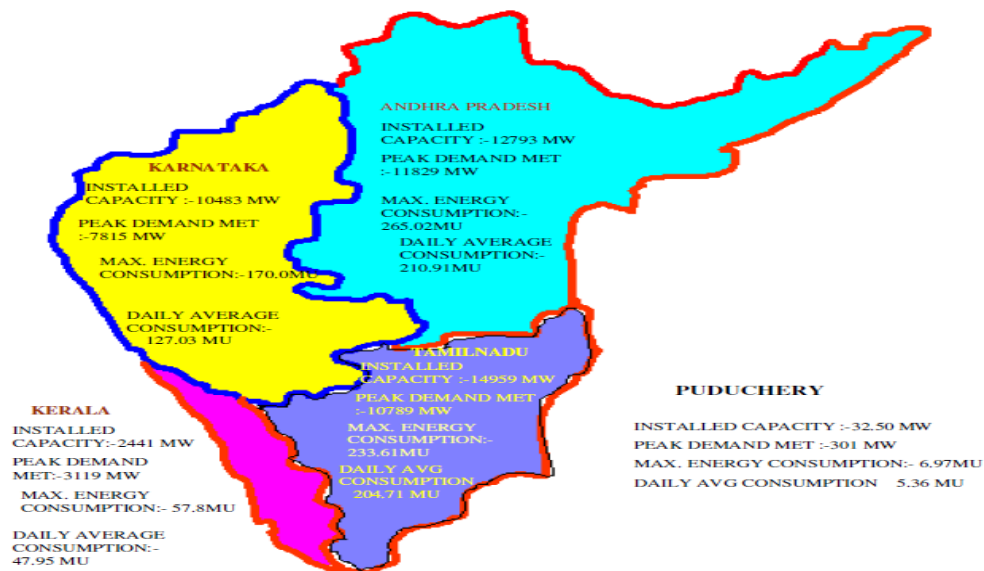
Email:poluripradeep238@gmail.com, contact no:09494215422

**Abstract---**Early electrical substations required manual switching or adjustment of equipment, and manual collection of data for load, energy consumption, and abnormal events. As the complexity of distribution networks grew, it became economically necessary to automate supervision and control of substations from a centrally attended point, to allow overall coordination in case of emergencies and to reduce operating costs. The development of the microprocessor made for an exponential increase in the number of points that could be economically controlled and monitored. Today, standardized communication protocols such as DNP3, IEC 60870-5 and Modbus, to list a few, are used to allow multiple intelligent electronic devices to communicate with each other and supervisory control centers. This enables migration to the digital substation, delivering smaller foot print, less wiring, increased personnel safety and improved reliability, resulting in reduced cost of ownership. In this project, testing of DNP3 protocol has been done to ensure whether the correct information is going to the master station (or) not and there by better communication is achieved. For this, the automation of testing of Host- and Sub- Communication Interfaces of RTU for DNP3 protocol for data points in the monitoring and control direction has been done. The test cases have been written in SATEEN Testing Console.

**Key Words---**RTU-Remote Terminal Unit, PCU-Process Control Unit, DNP-Distributed Network Protocol, HCI-Host Communication Interface, SCI-Sub-device Communication Interface, OPC-OLE for Process Control, OLE-Object Linking and Embedding.

## I.INTRODUCTION

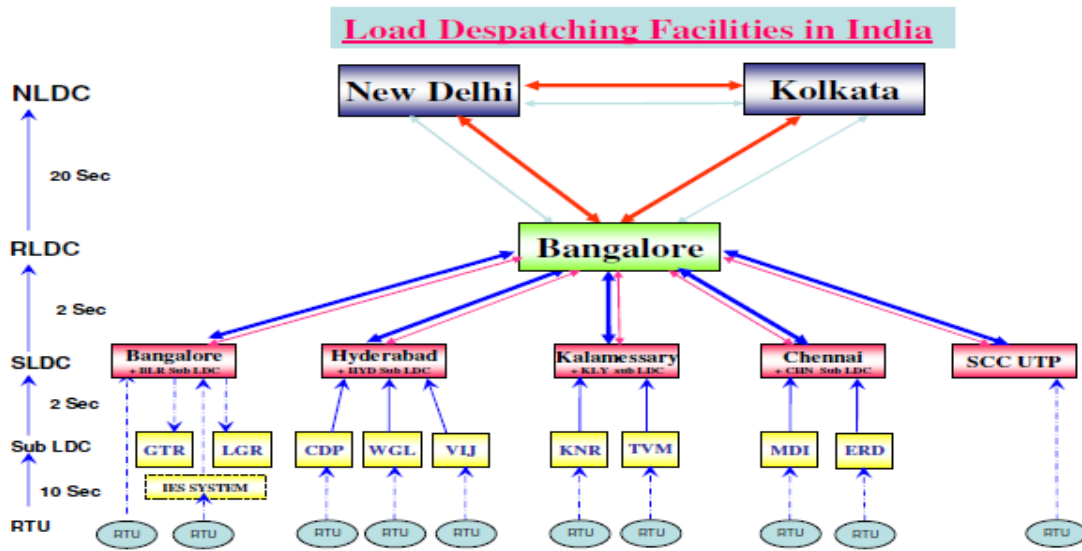
The development of Indian Electricity System hitherto had been on a Regional basis with five RLDCs established in the mid – 1960s having the responsibility to co-ordinate the integrated operation within each region. The Southern Regional Load Dispatch Centre (SRLDC) is one of these five RLDCs, located at Bangalore, the IT Hub of India and it is the nerve centre for monitoring and coordinating operations of the Southern India Regional Grid comprising the states of Andhrapradesh, Karnataka, Kerala, Pondicherry and Tamilnadu.



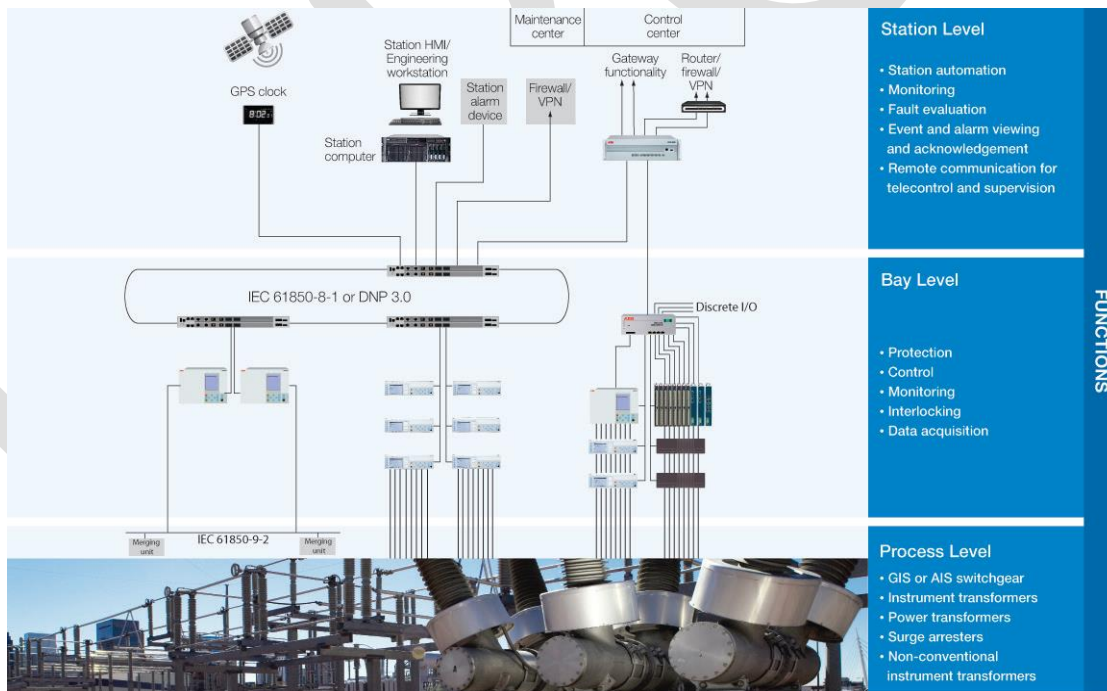
A. Unified Load Dispatch Scheme

Computerized load dispatch and communication facilities are an essential requirement in managing the control centre operations encompassing a large and complex interconnection such as Southern Regional Grid.

The hierarchy of ULDC in Southern Region is given below:



### B. Example of migration to the digital substation



The information is sent from process level to station level through a RTU. To send this information, a protocol must be maintained. The different protocols are DNP 3.0, IEC 60870-5 101 and IEC 60870-5 104. In this project, we are testing DNP3 protocol to ensure whether the correct information is going to the master station (or) not.

## **II. Literature Survey**

The present day Supervisory Control and Data Acquisition (SCADA) systems consisting of SCADA hosts, Remote Terminal Units (RTUs) and field devices monitor and control process equipment and systems from multiple locations and exchange data from various distributed control systems along the local and wide area networks. Communication within substations, between substations and to remote control centres is not new but has evolved from slower analog to faster digital communication. A large number of different serial SCADA and RTU protocols have been used by different utilities and manufacturers around the world resulting in costly and time consuming work with “protocol converters”.

The RTUs are pre-programmed to communicate with the central station SCADA and other networked systems in the form of protocols. Protocols are similar to languages, which allow the RTU/SCADA units to communicate with each other.

### **A. Existing System**

In a SCADA system, the RTU accepts commands to operate control points, Set analog output levels, and provide responses; it sends status, analog, and accumulator data to the SCADA master station. An RTU may be interfaced to multiple master stations and IEDs with different communication media (usually serial (RS232, RS485, RS422) or Ethernet). An RTU support standard protocols like Modbus, IEC 60870-5-101/103/104 and DNP3 etc. Automation of the protocol testing has to be done in order to ensure that data transfer from RTU to master station (i.e., SCADA) is done correctly.

### **B. Proposed System**

In this project, the automation of testing of Host- and Sub- Communication Interfaces of RTU for DNP3 protocol for data points in the monitoring and control direction has been done. The test cases have been written in SATEEN Testing Console.

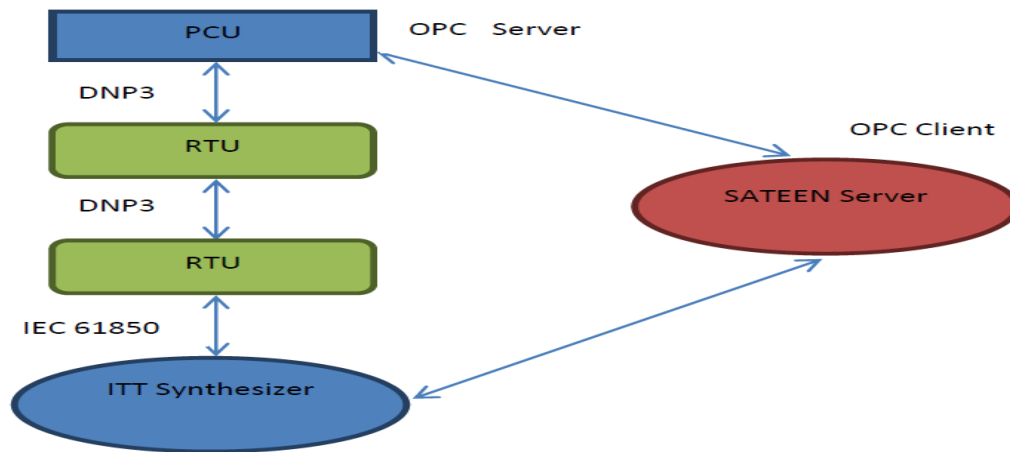
## **III.HOW TEST AUTOMATION FRAMEWORK FOR RTU IS DONE**

- In this paper, the automation of testing of Host- and Sub- Communication Interfaces of RTU for DNP3 protocol for data points in the monitoring and control direction has been done. The test cases have been written in SATEEN Testing Console.
- ITT Synthesizer is used to simulate data points of IED's. Two RTU's have been cascaded so that both HCI and SCI testing can be done simultaneously. PCU is used as a DNP3 master to the Master RTU.
- SATEEN server has OPC Data Access from PCU and ITT. This will enable us to write values through ITT and read the corresponding values from PCU for monitoring points, and write values through PCU for control points.
- The configuration of RTU and PCU has been done so that there is one point with each variation of a particular type of data supported by RTU560. Generation of XML files for PCU configuration is done using Excel DE tool. The polling modes of PCU can be changed by modifying the 'rtupoll' variable in the .ini files for the required line.
- A SATEEN Test Scheduler is used to run the scripts in a sequential manner at the required time.

## **IV. IMPLEMENTATION OF AUTOMATION TESTING**

In this project, test cases are to be automated for DNP3 protocol and these test cases are written in SATEEN (substation automation testing environment). The configuration of RTU and PCU has been done so that there is one point with each variation of a particular type of data supported by RTU560. Generation of XML files for PCU configuration is done using Excel DE tool. The polling modes of PCU can be changed by modifying the 'rtupoll' variable in the .ini files for the required line.

## A. Monitoring Direction: Setup



The setup for monitoring direction involves an IEC 61850 line from ITT Synthesizer (for simulation of IED's) to Slave RTU, which has a host DNP3 line with Master RTU. This RTU is further connected to PCU via a DNP3 line. The SATEEN server can interact and access data from PCU and ITT Synthesizer through OPC.

This will ensure that both SCI and HCI test cases can be verified as one RTU acts as a host and another act as a sub-device.

Test cases have been written by writing the ITT Synthesizer scripts and SATEEN scripts. Test cases have been written for the following data points (An example script is shown later in the report):

1. SPI (Single Point Input)
  - a. Object 1 Variation 0, 1 and 2
  - b. Object 2 Variation 0, 1, 2, 3
2. DPI (Double Point Input)
  - a. Object 3 Variation 0, 1 and 2
  - b. Object 4 Variation 0, 1, 2 and 3
3. AMI (Analog Measured Input)
  - a. Object 30 Variation 0, 1, 2, 3, 4
  - b. Object 32 Variation 0, 1, 2, 3, 4
4. DMI (Digital Measured Input)
  - a. Object 30 Variation 1, 2, 3, 4
  - b. Object 32 Variation 1, 2, 3, 4
5. BSI (Bit String Input)
  - a. Object 30 Variation 1, 2, 3, 4
  - b. Object 32 Variation 1, 2, 3, 4
6. MFI (Analog Measured Floating Input)
  - a. Object 30 Variation 1, 2, 3
  - b. Object 32 Variation 1, 2, 3, 4, 5, 7
7. ITI (Integrated Totals Input)
  - a. Object 20 Variation 1, 2, 3, 4, 5, 6, 7, 8
  - b. Object 21 Variation 1, 2, 9, 10
  - c. Object 22 Variation 1, 2
8. STI (Step Position Input)
  - a. Object 30 Variation 2, 4
  - b. Object 32 Variation 2, 4

## B. EXAMPLE ITT Synthesizer Script for SPI (Object 1 Variation 0)

```
//-----  
// Synthesizer Script: SPI_DNP3_obj1var0.cs  
// Created      : 6/9/2014 12:26:44 PM  
// Author       : ADMIN  
// Description   :  
//-----  
  
using System;  
using System.Net;  
  
using ABB.IEC61850.CoreTypes;  
using ABB.IEC61850.MetaModel;  
using ABB.ITT.SASynthesizer.SimulationUtils.ServerSimulator;  
using ABB.ITT.SASynthesizer.SubstationUtils;  
  
namespace ABB.ITT.SASynthesizer.SimulationUtils.Scripting  
{  
    public class SPI_DNP3_obj1var0: GenericScriptObject  
    {  
        public override void Main()  
        {  
            // [START SCRIPT]  
            SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind5.stVal", "True");  
  
            Wait(6000); //SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind1.q", new  
IEC61850_Quality(QualityValidity.Invalid, true, true, true, false, false, false, false, false,QualitySource.Substituted, false, true), true);  
            SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind5.q", new IEC61850_Quality(QualityValidity.Invalid, true,  
true, true, false, false, false, false, false,QualitySource.Substituted, false, true));  
            Wait(6000);  
            //SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind1.q", "Good" , true);  
            SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind5.q", "Good" );  
            Wait(6000);  
            //SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind1.stVal", "False", true);  
            SetValue("AA1J1Q01A2LD1/SP8GGIO1.Ind5.stVal", "False");  
            //Insert script commands here.  
            // [END SCRIPT]  
        }  
    }  
    // [START USER METHODS]  
    // Insert additional user methods here (event handlers, etc...)  
    // [END USER METHODS]  
}
```

### C. EXAMPLE SATEEN Script For SPI (Object 1 Variation 0)



### D. RESULT OF ABOVE TESTCASE

=====HEADER =====

=====BODY =====

SPI Value off to on change: True

on with invalid status: True

on->valid status: True

SPI Value change from on to off: True

SPI Values changes from ITT synthesizer to RTU.Values changes from RTU's to PCU via DNP3:\*\*\*\*\*\_-----  
-----\*\*\*\*\*

TimeStamp=2014-07-23 16:48:12.781; ItemName=SPI\_IND3; NewValue=1;

TimeStamp=2014-07-23 16:48:18.796; ItemName=SPI\_IND3; NewValue=1;

TimeStamp=2014-07-23 16:48:19.484; ItemName=SPI\_IND3; NewValue=1;

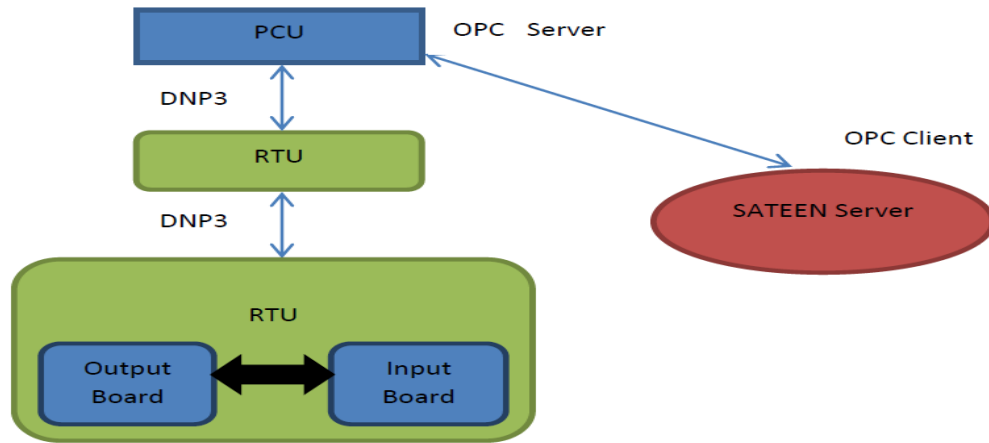
TimeStamp=2014-07-23 16:48:30.937; ItemName=SPI\_IND3; NewValue=2;

=====FOOTER =====

Testcase result: Succeeded

Verify timestamps for Obj1 var 0: Compare the event timestamps from MMS & DNP3 filter timestamp steps

## E. CONTROL DIRECTION: SETUP



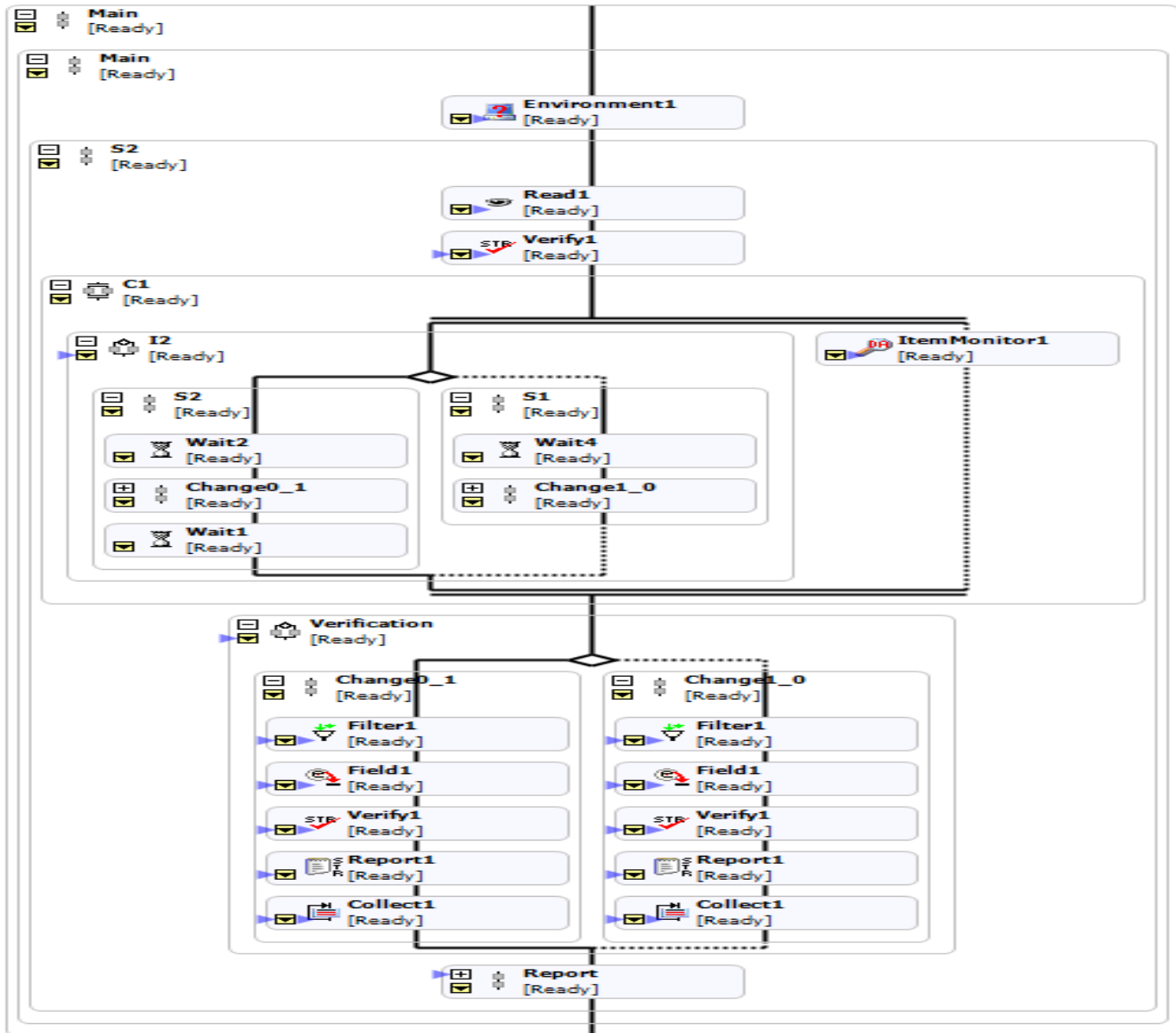
Here, the Slave RTU is configured with PDP boards such that each command point in a Binary Output Board is shorted with corresponding input point on a Binary Input Board. This will reflect any commands from the host as changes in the input data points of the RTU. Rest of the configuration is similar to the previous setup for monitoring direction.

For analog values, the previous setup is again used as some points in the simulated IED's of ITT Synthesizer can be used both as Command and Status points.

Test cases have been written for the following data points (An example script is shown later in the report):

1. SCO (Single Command Output)
  - a. Direct Operate (DO)
  - b. Select Before Operate (SBO)
2. DCO (Double Command Output)
  - a. Direct Operate (DO)
  - b. Select Before Operate (SBO)
3. RCO (Regulation Command Output)
  - a. Direct Operate (DO)
  - b. Select Before Operate (SBO)
4. BSO (Bit-String Output)
  - a. Object 41 Variation 2
5. DSO (Digital Set point Output)
  - a. Object 41 Variation 2
6. FSO (Floating Set point Output)
  - a. Object 41 Variation 3

### F. Example SATEEN script for Command point (For SCO - Single Command Output)



### G. RESULT OF ABOVE TEST CASE

=====HEADER=====

===== BODY =====

SCO value changed form on to off: True

SPI Values changes from ITT synthesizer to uSCADA via RTU:

\*\*\*\*\*\_\*\*\*\*\*

TimeStamp=2014-10-15 14:36:10.115; ItemName=SPI\_IND1; NewValue=2;

=====FOOTER =====



## V. Advantages of Automation Testing of RTU

- Reduce Operating Costs.
- Automation runs test cases faster than human resources.
- The development of DNP was a comprehensive effort to achieve open, standards-based interoperability between substation computers, RTUs, IEDs, and master stations (except inter-master-station communications) for the electric utility industry.
- Further benefits of the usage of DNP are less maintenance and long product life.

## VI. Conclusion

The automation of testing of Host- and Sub- Communication Interfaces of RTU for DNP3 protocol for data points in the monitoring and control direction has been done. Hence better communication between RTU and SCADA is being ensured with reduced costs and less maintenance compared to manual testing.

## REFERENCES:

- [1] Official URL of ABB Website [www.abb.com/substationautomation](http://www.abb.com/substationautomation).
- [2] Official URL of Wikipedia Website.
- [3] ISA2004 Paper “SCADA PROTOCOLS AND COMMUNICATION TRENDS”.
- [4] “Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems” by Gordon Clarke, Deon Reynders and Edwin Wright.
- [5] “DNP3 Communication Protocol Manual” by ABB,BANGALORE.
- [6] IEEE Std 1379-1997, IEEE Trial-Use Recommended Practice for Data Communications Between Intelligent Electronic Devices and Remote Terminal Units in a Substation , <http://ieeexplore.ieee.org/iel4/5327/14435/00660326.pdf>.
- [7] DNP 3.0 Protocol Functions Specification Set - The Basic Four , available from DNP User Group, [www.dnp.org](http://www.dnp.org).
- [8] Official URL for IEC Protocols [www.iec.ch](http://www.iec.ch).
- [9] Jim Coats, DNP3 Protocol , Presented at AGA/GTI SCADA Security Meeting, Aug 2002, [www.trianglemicrowoks.com](http://www.trianglemicrowoks.com).
- [10] IEEE Std C37.1-1994, IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control , <http://ieeexplore.ieee.org/iel1/3389/10055/00478424.pdf>.
- [11] Jim Coats, Comparison of DNP and IEC 870-5-101 , Presented at DA/DSM 97 meeting, DNPUser s Group, Rev. Sept.1999, [www.trianglemicrowoks.com](http://www.trianglemicrowoks.com).
- [12] Norwegian IEC 870-5-101 User Conventions , Revision no. 2.0, [www.statnett.no/Files/Open/IEC-R20\\_1.pdf](http://www.statnett.no/Files/Open/IEC-R20_1.pdf)