Test Procedure – PV System Anomaly Detection

I. **Yearly Requirements:**

주요 성능지표		단위	최종 개발목표			기술개발전 수준	※세계 최고수준 또는 수요처 요구수준	전체항목에서 차지하는 비중(%)	평가방법
			1차년도	2차년도	3차년도				
VPP 시스템	이상 데이터 감지 정확도	%	≥93	≥94	≥96	91	91 (Ref. [1])	5	1/2차:자체 시험 3차:공인 시험성적서

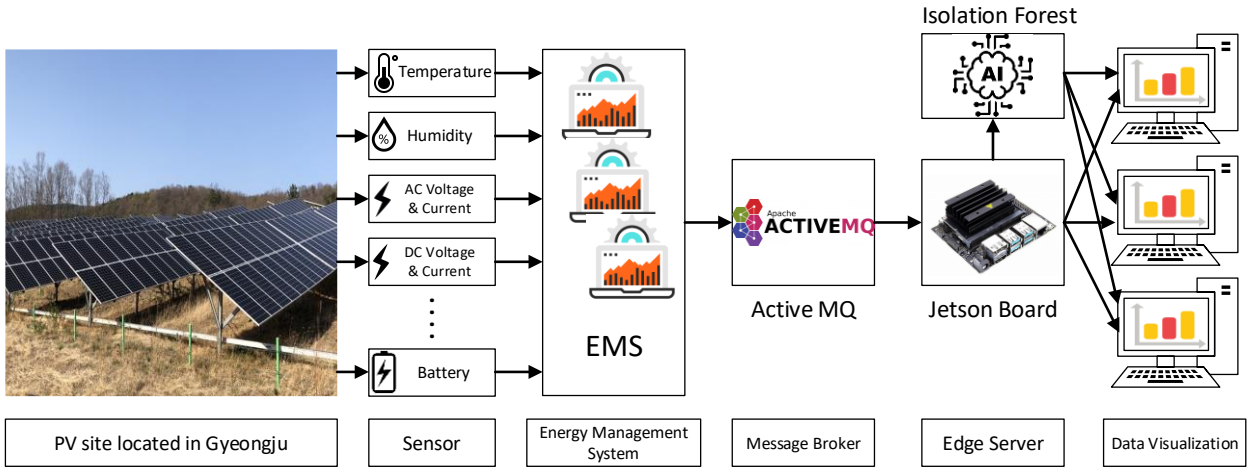
II. **Overall Architecture for Cloud Server**

• Step 1: Develop coding on the ActiveMQ platform side using Java.

• Step 2: ActiveMQ platform collects data from the all sensors and stores in PostgreSQL database.

• Step 3: Connect the python platform with data base system.

• Step 4: Apply Isolation Forest over the data and detect data anomaly.



<Figure 1. Architecture for data acquisition from sensors to database system>

Measurement procedure of collecting data and store in the edge server:

- All required sensor such as voltage sensor, current sensor, temperature sensor, and humidity sensor are connected to energy management system (EMS) using TCP and Serial directly to the input module of EMS depends on each sensor connectivity.

- The EMS collects all data from sensors continuously based on sampling time of each sensor. Every one second, the EMS will transfer the collected data to the edge server using MQTT protocol.

- To establish the MQTT connection between EMS and edge server, an ethernet connection or internet connection is utilized.

- After receiving the data from EMS, the edge server will store the data to its local database. In the database, the data will be grouped into each type of data including the timestamp of the data. The database type that will be used is PostgreSQL.

- After that, the edge server runs the AI algorithm for anomaly data detection using Isolation Forest. The result of the detection is shown in monitor.

Test environment and test method on edge server:

- The data from sensors will be received by the edge server for every one second. The edge server will be using a Single Board Computer (NVIDIA Jetson Nano).
- The edge server will be using the Linux Ubuntu Operating System. Inside the edge server, there will be installed a few software for the database system and AI algorithm.
- For the database, we will use PostgreSQL software because we did some tests using other database software and the result is PostgreSQL is lightest and fastest among other database software.
- To run the Isolation Forest algorithm, we use the most recent version of the Python programming language. We also use a few Python libraries to support the AI algorithm development, such as Tensorflow, Numpy, Scikit Learn, Pandas, Matplotlib.
- Periodically, the system will do an AI training process using recent data received in the database. The training process will result in a trained Isolation Forest model that will be used for the testing process (explained in Figure 2).
- Then, the newly trained Isolation Forest model is loaded by the testing program which will detect real-time anomaly of the PV system.
- The testing program will be in Python executable .py file format. The edge server will execute the .py file to produce the prediction and abnormality detection. Also, it will produce the accuracy value of the detection algorithm and print the detection result in the monitor.

III. Requirements and test scenarios:

a. 2nd Year Requirements:

Key Performance Indicators	Unit	Requirements	Current Status
Data anomaly detection by Isolation Forest	Percentage	**≥94%**	**94.58%**

b. MSVM model design and development:

Step 1: Receive data through database.
Step 2: Select feature through feature selection algorithm.
Step 3: Labeling dataset into three categories as follows:

Parameter	Condition	Range of parameter
Temperature data (Isolation Forest)	Normal	>45 Deg and <12 Deg
	Critical/Abnormal	otherwise

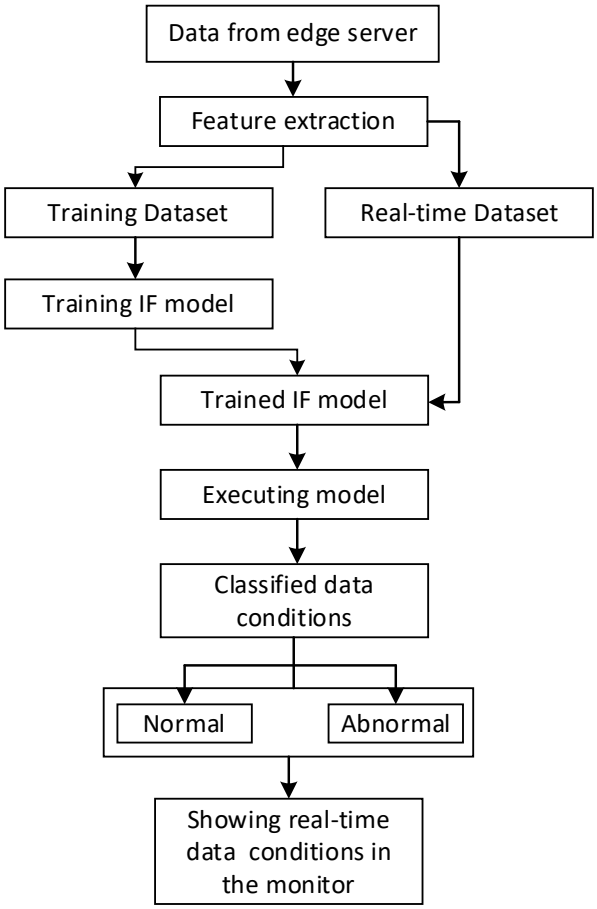
Step 5: Trained the Isolation Forest model.
Step 6: To calculate the accuracy of the system, we have applied this mathematical formula:

where, number of correct predictions = Number of true positive (TP) + Number of true negative (TN)
Total number of predictions = Number of true positive (TP) + Number of false negative (FN)+ Number of true negative (TN)+ Number of false positive (FP)

Step 7: Save the model.

c. Scenario
Procedure of system abnormal conditions detections by MSVM
Step 1: The sensor sends the data in real time.
Step 2: Receive real-time data through database.
Step 3: Loaded the real-time data in Isolation Forest saved model to determine the system anomaly conditions.
Step 4: Shows the real-time results of the Isolation Forest algorithm.

The working procedure has been shown in Figure 2.

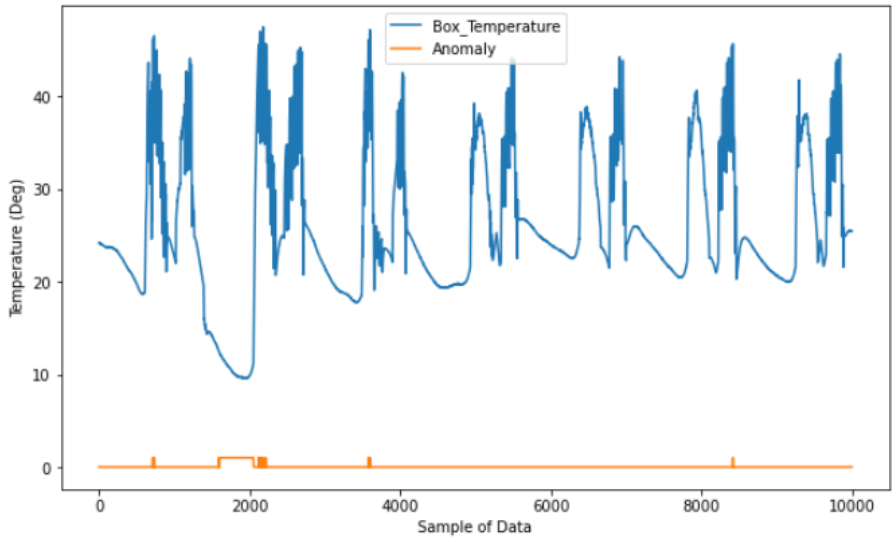


<Figure 2. Isolation Forest (IF) workflow.>

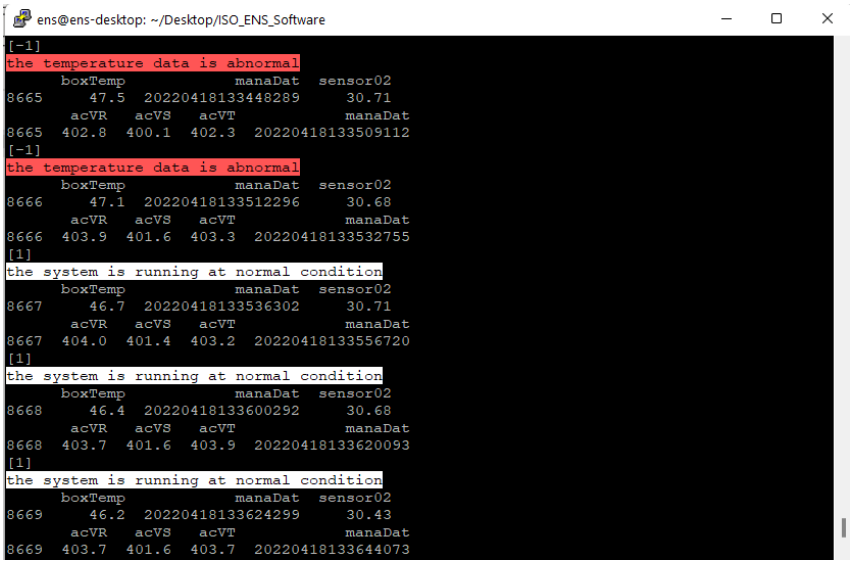
c. Hardware installation

< Figure 3. Jetson Nano installation on Gyeongju PV site >

d. Mobius IoT Platform Software



< Figure 4. Anomaly detection box temperature of the PV-ESS integrated system.>



<Figure 5. Anomaly detection box temperature of the PV-ESS integrated system.>