A Study of Handheld Meter Communication Function Inspection Tool

(Electric Power Research Lab：Lin, Che-I　Hsu, Yen-Feng)

1. Research Background

AMI is a system that carries the functions of measurement, collection, transmission, analysis of energy usage, capable of communicating with metering devices and is regarded as a bridge between electric utilities and end users. Although the basic purpose of electric meters is to measure the consumption and other parameters of electricity, the mass data retrieved by smart meters is used to provide electric companies with the ability to grasp the electricity consumption in real time through a communication system to increase the accuracy of the load forecast. In addition, smart meters can also receive and execute remote commands, such as switching circuit breakers, to ensure the safety of electric equipment. The mass data collected through AMI can also play an important role in smart grid applications, such as energy consumption analysis, tamper detection, power outage management, equipment diagnosis, etc., so as electric companies may benefit from reducing non-technical losses and assist in optimizing grid operation and energy consumption control.

Communication transmission is the key to the success of smart meter deployment. Due to TPC's AMI architecture design, smart meters and communication modules are implemented project by project and undertaken by different manufacturers. In case of abnormal situations like, e.g. the meter cannot be read remotely, to help TPC personnel to clarify the cause and responsibility of the occurrence and to inform the responsible manufacturer (whether meter or communication system) to perform related maintenance and warranty operations in accordance with the contract, it is necessary to develop relevant testing software and hardware to facilitate timely operation and interpretation by on-site personnel, to reduce the impact of meter failures on the public.

2. Research Content and Results

This tool is to be carried by the district office personnel to inspect the on-site meters. Therefore, its weight and size needs to be light, small and easy to carry. Considering that the communication interface of the meter may be upgraded in the future and to promptly update the firmware of this tool, it is necessary to have an additional opening for the Micro SD to load the firmware. Since, after searching, there is no available ready-made casing suitable for this tool on the market, a tailor made new mold is developed. The 3D diagram is shown in Figure 1, and the weight is about 100 grams.

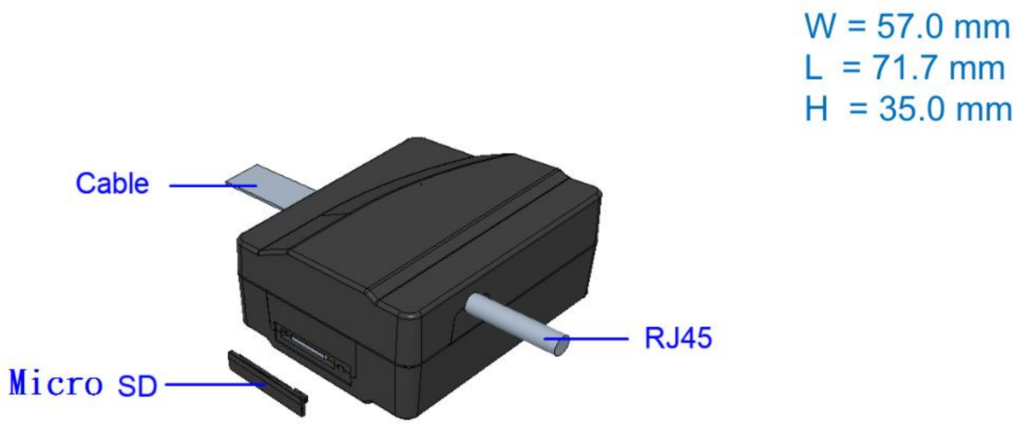

Figure 1. 3D Schematic Diagram of the AMI Meter Inspection Tool

The metering encryption keys in the AMI system is overall managed by the company's Key Management System (KMS). The key for each meter is granted by KMS when the meter is initialized. After initialization, any system or personnel that intends to communicate with the meter, obtain metering data, or give instructions to the meters, must have relevant keys to be authorized to do so. However, in the process of obtaining the required meter key by the inspection tool, the security of the key data must be ensured, and the risk of key leakage must be avoided. According to the design of key exchange process, the contents of the keys will be encrypted before they are sent to the KMS agent.

In addition to the key acquisition process mentioned above, the inspection tool development process also contains the development of testing tool firmware and human-machine interface (HMI). The firmware mainly contains the functions that will be used in the development of the inspection tools, such as Management AA creation and disconnection, FAN key life time, Meter Event reading, Register reading, Register setting, Push mode function, Load Profile Status reading, Load Profile History reading, and Midnight Register Profile reading.

As for the HMI, the inspectors will use the existing tablet computers to perform the inspection. After interviews, it is decided to implement the HMI as a web server built within the inspection tool, and to use a web browser to open the interface. The webpage is categorized into five tabs as follows: Communication Function Test, Register Reading, Existing FAN Keys, History Inquiry, and Software Update, as shown in Figure 2.

Figure 2 . Front page of the AMI Meter Inspection Tool HMI

The "Communication Function Test" tab mainly provides on-site personnel of TPC to verify the normal operation of the meter through automated reading and inspection. The query information, such as electric number, meter number, model code (brand), and metering time, can be read through the Verification Client. The object list of the P1 Specification can be automatically verified by clicking the "Start Test" button. If the verification is successful, the check mark will be displayed on the check box, a cross sign otherwise, the on-site personnel can therefore quickly distinguish the operating status of the meter. The inspection results will be automatically saved after each test execution. Lastly, the results can be downloaded on the tab of History Inquiry.

The tab of Register Reading allows the users to view the details of the data read in the inspection of the previous page. In contrast to the Communication Function Test tab, the Register Read tab allows the users to read the test objects individually, which is convenient for users to perform real-time numerical observations. After clicking an object and the Get button, the inspection tool will inspect the features of the objects and print the test results to the message box at the bottom of the screen. The way of presenting for each item varies according to the format of their sub-items. Reading a single item will display its single value. However, for multiple records such as historical values and event records, the default display is to show the closet to now 10 values or records.

The Existing FAN Key tab mainly allows users to query the FAN key and the expiration date of the current inspection tool. If there is no FAN key corresponding to the meter in the inspection tool or the key has already expired, the keys will be considered invalid.

The History Inquiry tab is to show the historical results of the Communication Function Test tab. The users can specify the brand and the time to limit the query range, up to ten queries at one time. When more than 10 queries, the time will be further limited. After specifying the results, it will be displayed on the page and can be saved as a PDF file.

Lastly, the Software Update tab provides a HMI for users to upload firmware or encrypted keys. The software of the inspection tool may be constantly revised, in case of standard updates. As for the key upload, the key will be directly transferred from the KMS agent to the inspection tool. However, this tab also supports manual uploading of keys when necessary.

3. Conclusion

The major difference between smart and traditional meters is the ability of exchanging real-time data through communication systems to the meter data management systems at the control center. TPC has accumulated fruitful experiences from previous high-voltage AMI and low-voltage AMI demonstration systems, and knows well that the efficiency of the communication system determines the key factor for the success of the overall system. However, the installation sites of electric meters in Taiwan is complicated. It is difficult to achieve the expected success rate of automatic meter reading by using a single communication technology. Therefore, TPC has decided to separate the metering unit from the communication unit. The metering unit may be taken care of by the traditional meter manufacturers, and the communication part may be deployed by professional communication manufacturers as a communication bridge between the meters and the back-end system. Because the communication unit adopts modular and pluggable design, communication manufacturers can choose the best communication technology for the field where the meter is installed according to local conditions. For example, power line carrier (PLC) may suit for high-rise buildings, NB-IoT for open-field buildings, and low-power RF for dense departments to improve the reliability and success rate of communication. In the future, communication technology will continue to evolve. When advanced technologies such as 5G are mature, we only need to replace communication modules with new technology modules, instead of replacing the entire meter, to significantly reduce costs.

Although modular meters can provide the above-mentioned advantages, when an abnormal situation such as poor communication occurs in the electric meter at the user end, it is difficult to immediately distinguish the malfunction caused by the meter measurement or communication. In the past, the electric meters had to be removed and send back to the laboratory for testing, which is time consuming and laborious. Therefore, this project developed a portable handheld meter near-end inspection tool, capable of performing complete meter communication interface diagnosis on the user side. Once the communication problem is confirmed, we only need to replace the FAN module . The entire meter does not need to be disassembled. This will significantly shorten the working time and process. The newly developed inspection tool has been distributed by the Distribution Department, the entrusting party, to the District Offices under its jurisdiction for use. The framework and testing process of this inspection tool are user-friendly and can be operated with an existing tablet computer. The personnel of the District Offices can get started after simple learning.