Smart Street Light Metering – Revised September 2020

Originally published in April 2017

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Executive Summary

The past several years has seen an increase in popularity for smart street lighting. This interest is primarily driven by cities looking to reduce energy and labor costs. Thus, legacy city street lights are being exchanged for new more efficient high wattage LED lighting. In an Iowa case study LED street lighting had reduced energy consumption of the retrofitted luminaires between 29% and 63%. In 2016 it was estimated that there are over 1,000 active LED street light projects in 90 countries[1]. Over the next ten years cities and utilities will network 138.7 million street lights[1].

It is common to view, housed on top of street lights, an electronic module- *see Figure 1*. These electronic modules primarily perform dusk to dawn switching. The emergence of newer generation modules, in addition to dusk to dawn switching modules using photo controllers, provide WI-FI hotspots, transmit GPS and diagnostics information and measure energy consumption using Per-pole utility-grade metering accuracy.

Figure 1 Smart Street Lights

Radian Research, Inc with their WECO Family of meter test boards and systems is the leading supplier of electricity revenue meter test equipment and software for the ANSI metering market. This article looks at common questions raised by electric utilities on how to adapt their existing testing solutions to accommodate the newer generation of smart street lighting modules fitted with utility grade metering accuracy.

Street Light Module Suppliers

A dozen or more suppliers of smart streetlight control technology exist today with many more to arrive on the scene over the next few years. Module suppliers include:

- Landis+Gyr
- GE
- Sensus
- Telensa
- CIMCON
- SELC
- Dimonoff

These suppliers offer a broad range of module features and communication infrastructures to choose from, some examples are listed below. What each module contains will depend on the needs of the consumer as to which solution best fits their needs:

1) **Functionality**
   Dimming, Diagnostics, Metering, etc.

2) **Communications**

   Gridstream, SilverSpring, Flexnet, etc.

3) **Control & Diagnostics**

   Scheduling, Alarm, Maintenance, Asset Management, etc.

Figure 2 Street Light Module

Lighting Standards & Consortiums

The market for smart street lighting is relatively new and evolving rapidly. This has led to several different designs to accommodate the various features found in each supplier's modules. A few Street Light Consortiums exist today or are in early development, that offer a variety of resources to guide municipalities, utilities, and others in their evaluation of smart street lighting products.

Street Light modules have one thing in common, the mechanical interface to the luminaire is based on the NEMA ANSI C136-10 - Roadway and area lighting equipment locking-type photocontrol devices and mating receptacles as well as Physical and Electrical Interchangeability and Testing, an approved American national standard, *see figure 3*.

A three position (ANSI C136-10) and five/seven position (ANSI C136-41) receptacle is available to accommodate two or four dimming/signal contacts rated at 10VAC/0.10 A max. The three power contacts are rated at 480 VAC/15 A ma

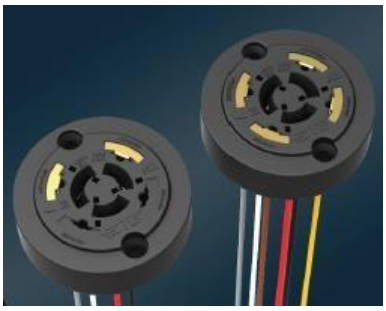

Figure 3 ANSI C136 Light Module Locking-Type Receptacle

Unlike the ANSI C12 Standards for Revenue billing meters, the author of this article, at time of writing this article, was unable to find any ANSI Standard applicable to the accuracy test for the embedded utility grade meter found within street light module design.

Module Testing

RADIAN is currently engaged in the Smart Street Light Module testing needs of North American developers, manufacturers and the utility end user. Each opportunity provided RADIAN insight into the design of the Smart Light Module and specifically the decisions facing utilities when selecting vendors for modules that contain a utility-grade revenue meter.

In some countries, the utility is very specific. “If the device does not have a display, then it does not fall under the same meter testing regulations as electricity billing meters”

In other regions, the utility decides how the module is tested for both functionality and accuracy. The utility grade meter within a Smart Light module is essentially a 1% class, single-phase, two-wire meter.

With an appropriate test board adapter, the device can be energized, and load applied using existing WECO true three-phase meter test boards. If the test board has three independent current channels and reference inputs, it may be possible to connect and test three modules simultaneously. The only limiting factor is the methods used to determining the KWh value.

Meter Accuracy Determination

Traditional methods for testing the accuracy of a utility-grade meter involve applying a load, typically Full Load, Light Load and a load where the phase relationship between voltage and current is 60 degrees (0.5 Power Factor). Furthermore, typical methods for testing the accuracy of revenue meter is to apply a load while monitoring pulses being emitted by the meter and to compare the impulse with the impulse emitted from an independent energy reference standard. Alternatively, the meter’s internal registers are interrogated to determine the consumed energy between a specific start and stop time and compared with a reference standard for error determination.

In some module design reading the register is the only method to read the consumed energy and is accessible using onboard network communications (i.e. Silver Spring Network) as found on CIMCON brand or Near Field Reader, as found in the Telensa brand. Other module manufacturers have opted for the conventional metering infrared or visible impulse. A Standard has yet to be written that defines test methods for accuracy determination. Therefore, while it is not yet obligatory to accommodate a impulse output within lighting module design. Should a need for module meter calibration be required by a developer or utility one or more methods may be implemented to determine accuracy.

One or more of these methods may be available.

1) Kh/Ke Impulse Output.
    a) InfraRed.
    b) Hard wired.
2) Near Field Communications (NFC).
3) Network Communications (e.g. Silver Spring, Flexnet etc.).

Infra/Visible Light Impulse – easiest and most familiar method. Existing testing solutions are already setup to test using an array of different types of Optical sensors. WECO test board solutions have an array of different optical sensors that can be oriented appropriately for kh/ke impulse measurement.

Hard-Wired Impulse Output – Some Street Light modules have been developed with a hard-wired connection for electronic impulse output. Connections might only be accessible by module cover removal while other designs have opted to utilize connections normally assigned for dimmer control found on the base of the module. Regardless care must be taken to ensure the impulse output characteristics match the test board impulse input requirements. Failing this, an electronic impulse level shifter and digital isolator circuit maybe required to ensure impulses are communicated and measured correctly. Note: a terminated hardwire connection may require that the module cover be removed exposing hazardous voltage during test, the operator should observe compliance with their own utility safety requirements before making connections.

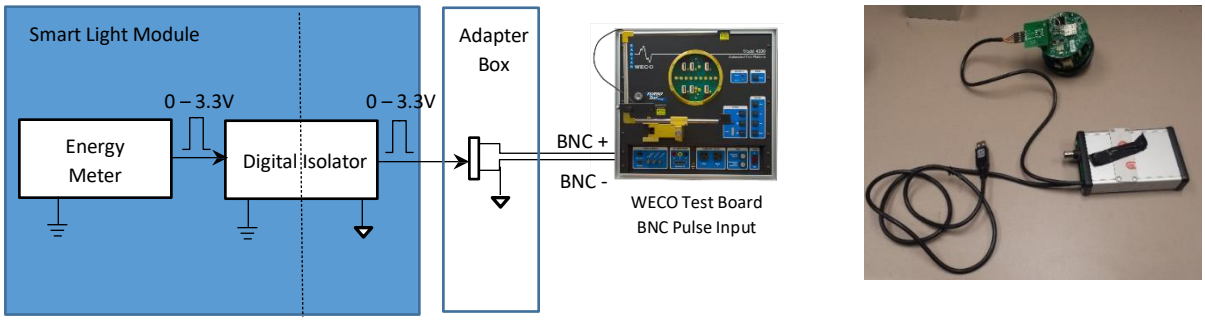

Figure 4 Module Impulse isolation adapter block diagram.

Near Field Communications - Street light modules that implement impulse methods described above are tested individually due to the limitations of available impulse comparators. Alternatively, modules with Near Field Communications (NFC), or rely upon onboard network communications to relay KWh and other information, can often increase testing throughput. NFC technology is common within the contactless payment industry but less known within meter testing. At least one Smart Street Light Module manufacturer uses NFC technology today. To accommodate this design requires a Near Field Reader (NFR) in proximity to the module while being tested. Accuracy testing requires a register read before and after the load is applied. A recent implementation at Georgia Power required that the WECO Model 2350 (*see figure 5*) and WECO 8000 Test Station software (*see figure 6*) be modified to access kWh reading as determined by the vendors supplied NFR sensor and software.

Figure 5 Three position WECO 2350 Test Boards – Testing nine Smart Light Modules simultaneously.[2]

Network Communications uses onboard wireless technology to communicate with the Smart Street- light module. A testing solution would need access to the wireless technology software to be able to seamlessly access information during the test.

Both NFC and Network Communication protocols require additional software used and accessed in conjunction with test board measurement software and database. While this generally is not a problem, care must be taken to synchronize the vendor's software initialization to start measurement and stop measurement. This must be controlled carefully to ensure the test boards internal reference measurement see the same energy over the same period.

Figure 6 Light Node Testing using WECO 8000[2]

Load Side vs Line Side Power

One street light module adaptation is the load side powered meter. In a conventional socket base meter, the meter power supply is connected to the line side of the meter connections. The energy consumed to operate the meter is not measured by the meter, and therefor that cost is not passed on to the customer.

Many street light meters have changed such that the power supply of the meter is powered from the load side of the meter connections. This change means the meter is measuring its own power supply consumption. This configuration allows the utility to measure the total operating cost of the light and meter.

This becomes a challenge when performing accuracy testing on the meter. At the energy levels, these meters are tested, the consumption of the meter can cause upwards of 6% in error of registration. This is an unacceptable error for any utility.

Radian designed the 4050XT True Three Phase Automated Test Platform (*see figure 7*) to handle this challenge. The 4050XT allows for measurement of the load side meter consumption to eliminate this error.

Figure 7 Light Node Testing using WECO 4050XT

The diagram in Figure 8 demonstrates how the test board is configured to measure the energy consumption of both line and load side powered light node meters.

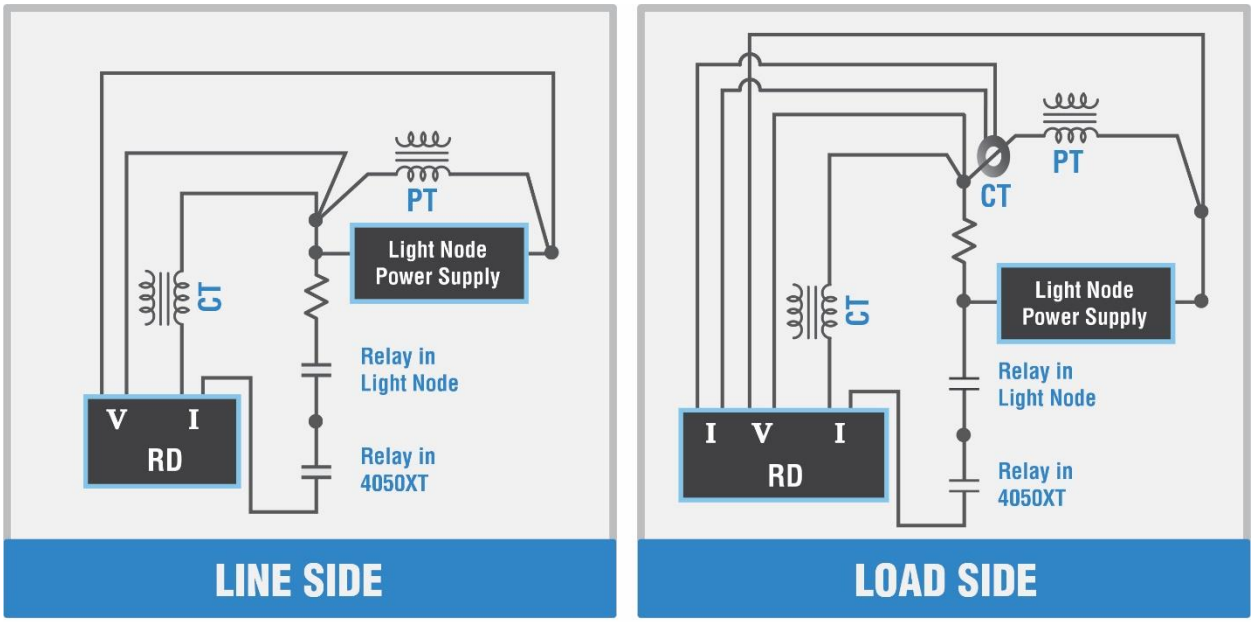

Figure 8 How to measure the energy consumption of both line and load side powered light node meters.

From the perspective of the 4050XT operator, load side meter testing will not change their testing process at all. The changes are made via custom meter forms created in our suite of WATT-Net™ software packages.

Summary

The papers information and recommendations represent the experiences of a test equipment manufacture to test a new generation of smart street light modules. As can be seen, each street light module supplier takes a different approach to allowing utilities to access module meter measurement data. This places the emphasis on the customer (utility) to ensure that they select a module supplier that can interface easily with their existing ANSI C12 meter test solutions. As an equipment supplier involved in testing meters, we've seen the need for a range of different ANSI C12 to ANSI 136 interface adapters as well as modification to our software to transfer meter data from the module supplier's software to our test software. While smart street light module technology is relatively new and evolving, future revisions to the ANSI 136 Standard would certainly help assist with standardizing on how the modules KWh measurements are communicated to accommodate module design differences. Meanwhile, in the absence of any Standard for Module testing, RADIAN resources are available to evaluate the needs of this emerging technology and will continue to work with module developers and utilities to accommodate their testing needs.

Useful References

DOE Municipal Solid-State Street Light Consortium - https://energy.gov/eere/ssl/doe-municipal-solid- state-street-lighting-consortium.

NEMA ANSI C136 - Solid State Light Sources Used in Roadway and Area Lighting.

TALQ Consortium – www.talq-consortium.org

Smart Street Lighting - Navigant Research.

[1]*Source courtesy of Global LED and Smart Street Lighting: Market Forecast North East Group, LLC.*

[2]*Test board images courtesy of Georgia Power.*