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Clair Bright

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Editor-in-Chief
Lynnette Reese | lreese@extensionmedia.com
Managing Editor
Anne Fisher | afisher@extensionmedia.com
Senior Editors
Caroline Hayes | chayes@extensionmedia.com
Dave Bursky | dbursky@extensionmedia.com
Pete Singer | psinger@extensionmedia.com
John Blyler | jblyler@extensionmedia.com

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Advertising / Reprint Sales
Vice President, Sales
Embedded Electronics Media Group
Clair Bright
cbright@extensionmedia.com
(415) 255-0390 ext. 15
Sales Director
Elizabeth Thoma
(415) 244-5130
ethoma@extensionmedia.com

Marketing/Circulation
Jenna Johnson
jjohnson@extensionmedia.com

To Subscribe
www.eecatalog.com

Extension MEDIA

Extension Media, LLC Corporate Office
President and Publisher
Vince Ridley
vridley@extensionmedia.com
(415) 255-0390 ext. 18
Vice President & Publisher
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Home Efficient Home

How an RF smart plug can sweeten home energy savings by letting energy consumers see power consumption in context

By Salil Jain and Alok Kumar Mittal, STMicroelectronics

Salil Jain

Alok Kumar Mittal

With everything from refrigerators that help with grocery lists to secure doorbells that identify guests now connecting to the internet, energy consumption is soaring. However, solutions are coming online which make it possible to identify the energy usage of each device in relation to the whole and thus determine the most efficient timing and length of operation.

How would such a device work? It would need to be multipurpose, portable, and compact with the ability to measure and control electrical devices from any standard outlet in the home. It would need the ability to monitor energy consumption, turn appliances on or off, schedule loads for appliances such as clothes dryers and hot water heaters, and set alerts using easy smartphone apps.

Features necessary to successfully keeping an eye on power use and responding with actions that help maintain energy efficiency include:

- A meter design with wireless connectivity
- Bluetooth Low Energy (BLE) 4.1 connectivity for the control and metering panel as well as smartphone connectivity to enable the control of household appliances via an energy consumption dashboard
- The ability to control the loads of some appliances, including AC Induction fan speed, heaters, and incandescent lamps
- Scheduling
- A Near Field Communication (NFC) interface so that storing the logs to configure the design is possible
- Isolated USB interface for GUI and calibration: may be required during the development and calibration
- Rated voltage: 240 VAC, Rated Current: 12A (TYP)
- Power rating: Up to 2400W / 12 Amps
- Power consumption of plug: 0.7 Watts (Max.)

CONTROLLING CONSUMPTION

One example of a reference design that encompasses the above features is STMicroelectronics' RF Smart Plug for IoT home automation applications. It contains all the core functionality required for secure wireless communication, keeping energy consumption data in the user's control.

The smart plug is designed with the STM32L443 Microcontroller (MCU), based on the Arm Cortex-M4 core. This low-power MCU features crystal-less USB, 100 DMIPS, and an operating voltage from 1.71 to 3.6V.

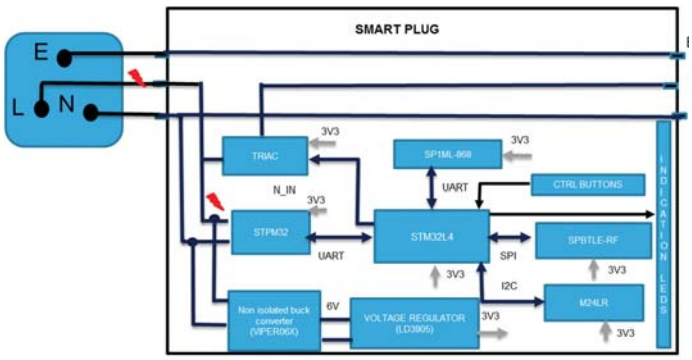

Figure 1: One example of device that facilitates power consumption measurement and control is the STMicroelectronics RF Smart Plug.

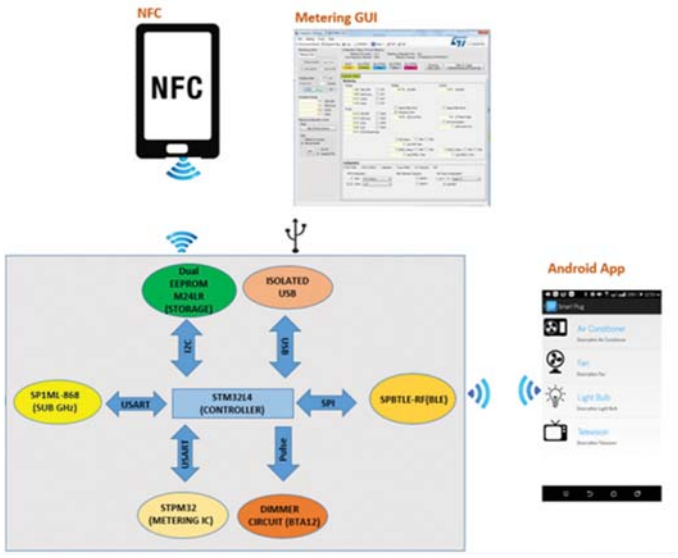

Figure 2: The STPM32 metering IC tracks power, voltage, current, and power factor parameters using wireless connectivity over SUB-GHz or BLE.

With wireless connectivity over SUB-GHz or BLE, the ability to measure energy parameters like power, voltage, current, and power factor is provided using the STPM32 metering IC (Figure 2). The MCU communicates with BLE using a Serial Peripheral Interface (SPI), with the help of the Triode Alternating Current Switch (TRIAC) to achieve load control. An isolated USB port and dual EEPROM (M24LR) allow communication with the Graphical User Interface (GUI) and Near Field Communication (NFC).

TWO MODES

The RF Smart Plug has two modes. In the first mode, the device acts as a BLE peripheral device, which can be connected for control along with monitoring. In the second mode, the device is a manufacturer-specific beacon, which is connectable. It advertises its metering parameters so that multiple Android smartphone brands can monitor the plug, but only the specific bonded device will be able to connect. This application runs at 48 MHz for optimal performance, while power consumption is in between 40 to 50mA.

Figure 3 highlights all the sections of the RF Smart Plug, showing how form factor and reliability challenges are met. This makes for a small, portable device, usable in any outlet in the home.

The non-isolated buck converter (Figure 4) is designed using STMicroelectronics' VIPER06Xs. It is used with Pulsed Wave Modulation (PWM) operation at 30 kHz with frequency jittering for lower Electromagnetic Interference (EMI), with standby power less than 30 mW. This type of power supply suits low current applications that demand a small form factor.

In our design, the output of supply is set at 4.5V. STMicroelectronics' LDO LD3905 voltage regulator is used to power up all the analog and digital sections with output voltage and current at 3.3V and 500mA, respectively.

CURRENT CONTROL

A Triode Alternating Current Switch or TRIAC is a three-terminal component used to control the current. It gives AC switching for various electrical system applications. In addition, it can change the duty cycle of the AC voltage applied to the lights/load being controlled. Figure 5 shows the status of AC voltage at 50% duty cycle and use of a Zero Cross Detection (ZCD) for a dimming reference point to fire the TRIAC.

Figure 6 explains the GATT and GAP role, and Figure 7 describes the State Machine of the RF Smart Plug.

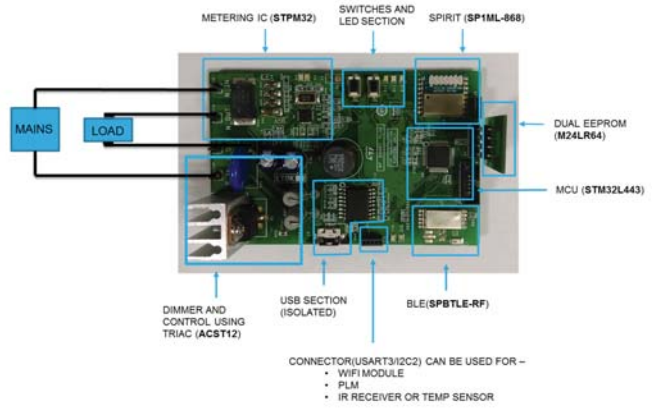

Figure 3: The two RF Smart Plug modes include: Bluetooth Low Energy peripheral device; connectable manufacturer-specific beacon.

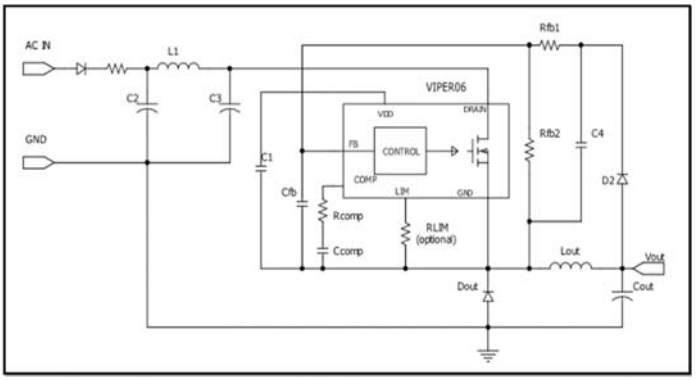

Figure 4: Non-Isolated Buck converter

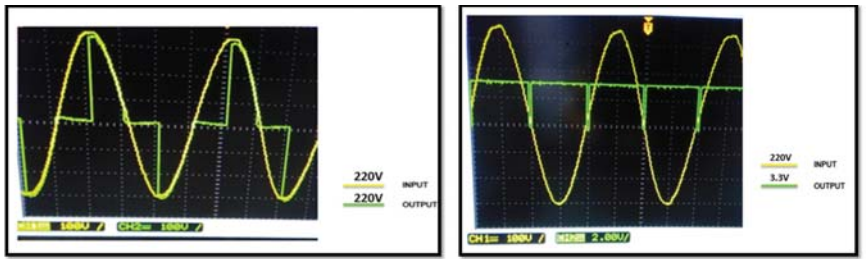

Figure 5: TRIAC at 50% duty cycle and ZCD

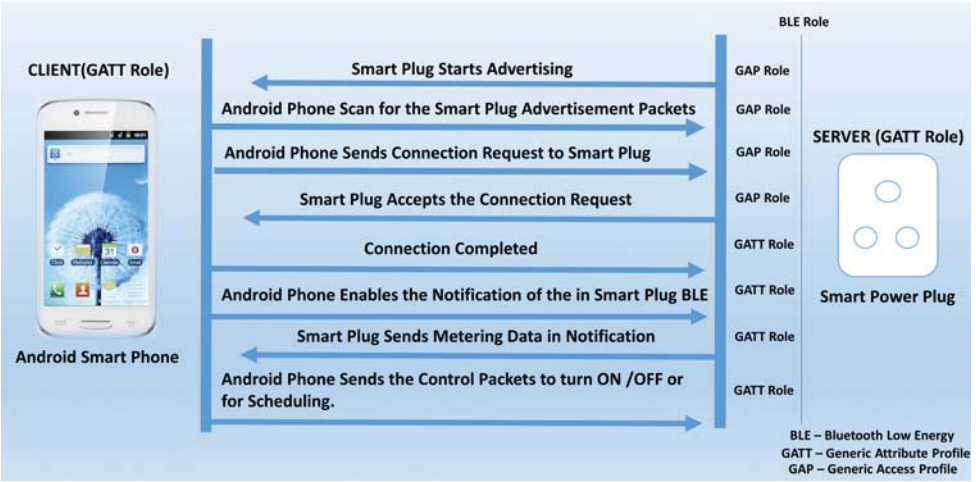

Figure 6: Functioning Principle

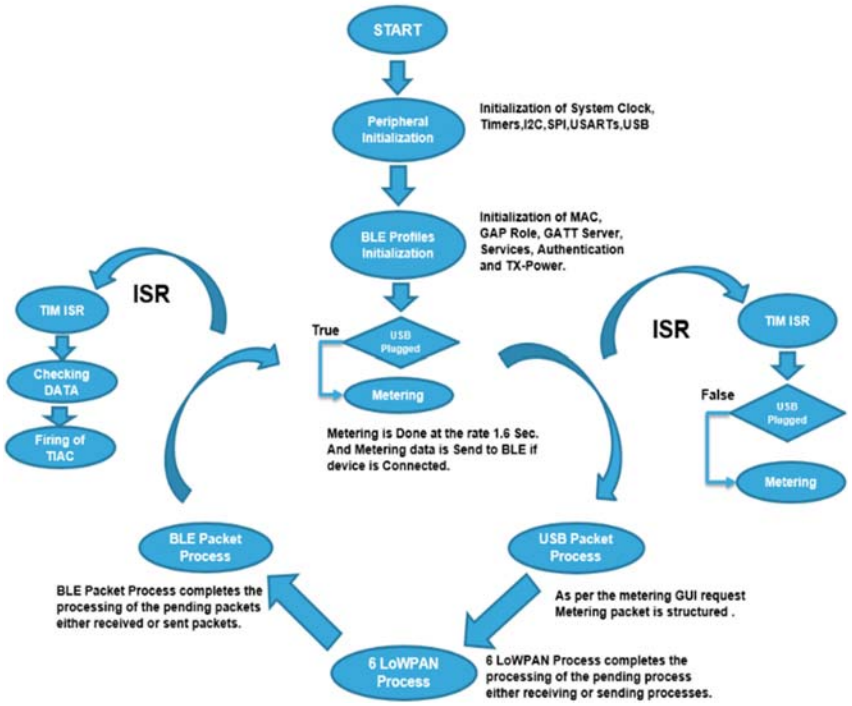

Figure 7: RF Smart Plug State Machine

ANDROID APPLICATION

An Android application designed by STMicroelectronics can be used for the Turn On/Off of the Load, Scheduling, and Dimming features.

The user can also view the metering parameters using the same application. The Android App can be downloaded by following the steps shown in Figures 8 and 9.

SUMMARY

This Smart Plug reference design is a system solution for energy management and saving with wireless connectivity over SUB-GHz or BLE. It provides the ability to measure energy parameters like power, voltage, current, and power factor using the STM32 metering IC. With all the core functionality required for secure communication, it provides a fast and flexible alternative to make homes smarter, money-wise, and safer.

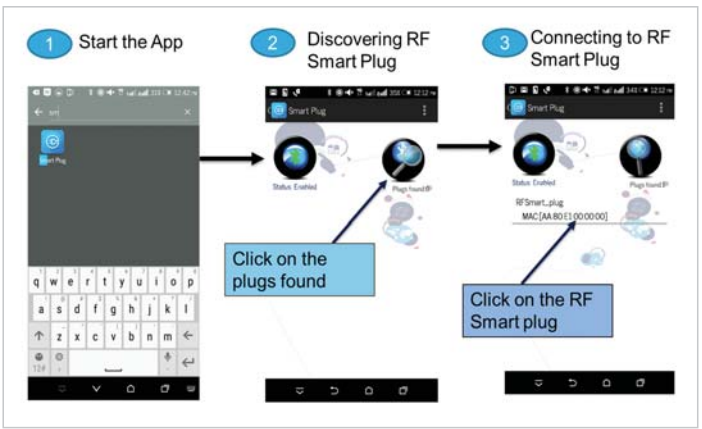

Figure 8: RF Smart Plug Android App

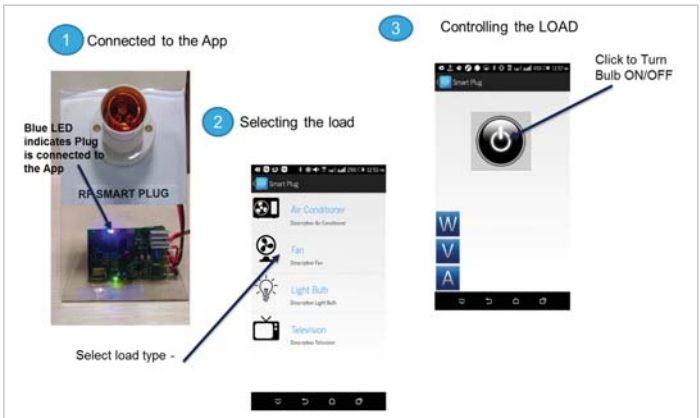

Figure 9: RF Smart Plug Android App Settings

Salil Jain is currently working as a Technical Leader with STMicroelectronics, and has seven years of experience as a designer, architect, and project leader of electronics systems for multi-disciplinary domains (HW & SW). His main area of interests are BLE Mesh, Metering, and Healthcare. He is the coordinator of IEEE under Special Education Initiative and is also the STM32 Microcontroller training member under e4i (Electronics For India) initiative.

Alok Kumar Mittal is currently working as a Group Manager with STMicroelectronics and has more than 20 years of experience in Embedded Systems Design. He has worked on applications around USB, mass-storage, energy metering, and wireless communication. His main responsibility includes architecture design of system solutions and their development, including integration with software applications. He has six patents granted to his credit. Currently, his area of interest is the BLE (Bluetooth Low Energy) Mesh solution.

Seamless Transport Ticketing for Smarter Cities

How migration from proprietary systems and the increasing prominence of open standards are making commuters' lives easier.

By Philippe Martineau, OSPT Alliance

The world's cities are growing at a phenomenal rate. It is estimated that by 2050, 66% of the world's population—a staggering 6.419 billion—will be living in urban areas. With this rise come two main developments. One, city services such as the transport network must be capable of serving greater numbers of passengers quickly, effectively, and securely every day. Two, with growing urban populations comes greater connectivity. Combined, this amounts to an even greater demand for smarter, more seamless operations to ease the consumer's day-to-day life, facilitated by advances in technology.

Cities are getting bigger, more connected and crucially, smarter.

South America is one region currently experiencing such rapid urban development. In an attempt to deliver a more frictionless service to its rising number of smart city travellers, the transport ticketing ecosystem in the country is in the process of upgrading and restructuring.

LEGACY AND OTHER OBSTACLES

Despite a sincere desire to support innovation and deliver superior experiences for passengers, transportation agencies have had to overcome significant legacy obstacles to deliver any considerable advances. Throughout the market, in South America and beyond, operators are bound to customized proprietary fare collection systems from a single-source supplier.

As a result, accommodating new technologies and the costs to upgrade systems are dictated at the pace and the price of the incumbent vendor. The dominance of proprietary systems in the transport ticketing market, and the lack of ownership of the ticketing specifications by the transportation agencies is, undoubtedly, the central factor hindering innovation.

TRANSFORMATIVE

Standardization, as it has done across industries such as IT and telecoms, can have a transformative power. In transport ticketing, it can level the playing field and be the key to driving effective, sustained innovation. One example of a non-proprietary standard is CIPURSE™, which is developed and managed by OSPT Alliance, a member-driven industry association. CIPURSE is fully configurable and adaptable to the requirements and innovations of the transit ticketing community.

SIMPLER

Operators with infrastructures built on proprietary systems must wrestle with costly, complex upgrades to their systems when accommodating each emerging payment form factor and/or security scheme. Standardization simplifies these complexities.

Built on the international smart card command (ISO 7816) and interface (ISO 14443) standards in conjunction with AES security (FIPS 197, ISO/IEC 18033-3), CIPURSE supports each fare media device with the same security protocols. This means there is no need to upgrade CIPURSE compatible readers and terminals when incorporating new ticketing formats—whether that's adding in mobile

Figure 1: Arguably the smart city's nervous system, its transportation network is stepping up with the help of open standards to meet the needs of more and more travelers quickly, effectively, and securely every day.

ticketing acceptance or accommodating wearables, CIPURSE also offers the interoperability and scalability to simplify this process into adjacent markets and services.

RAISING THE GAME

With open standards, technology benefits from increased innovation, too. Working collaboratively, OSPT Alliance's member organizations share a vested interest in sustaining and advancing standards. Operators have the freedom to select the best vendors and business models for their solutions, which in turn offer new players a greater opportunity to showcase their offering, promoting healthy competition in the industry.

Let's take a closer look at how CIPURSE is driving projects forward in South America.

MITIGATING FRAUD AND ERRORS

The mature and secure CIPURSE standard offers an answer to mitigating losses due to fraud, system errors and cash handling. In addition, with some big cities in Brazil, for example, passengers may need up to three cards for travel. CIPURSE's interoperability enables all three cards to be combined into one. The benefits for the consumer are obvious, but this saves the operators a number of logistical headaches and costs, too.

However, hesitancy persists surrounding the supposed high costs and complications of replacing proprietary systems. Experience has now shown this 'rip and replace' overhaul is a myth, and one that Brazil-based OSPT Alliance member Planeta Informática is keen to dispel.

Planeta Informática's mission is to support transport players across the continent to begin the process of migration from proprietary solutions to the benefits of open standards, offering 'off the shelf' CIPURSE solutions and consultancy support to system integrators and transport operators.

As neither the ticket data nor the back-office system must change to enable CIPURSE deployment, upgrade costs are minimal. A small secure application module, or SAM, simply needs to be integrated into the gates and validators of the system to add recognition of CIPURSE into existing systems.

Planeta Informática has been an industry-leading SAM provider for the last 10 years, with more than 200,000 SAM devices currently deployed, supporting 30 million users per day across South America. Utilizing virtualization technology, its latest SAM device enables the simple integration of CIPURSE into existing systems without having to change the current application software, validator software, or host system. Plus, as CIPURSE can operate alongside legacy solutions, a phased, cost-effective approach to card replacement can be taken, as existing cards can continue to be used.

MINUS PAIN, RISKS, COSTS

It's with this simple approach that Planeta Informática has launched what's set to be the largest scale CIPURSE deployment project to date in Cuenca, Ecuador. With the deployment now complete, it is expected that a full migration to CIPURSE card usage will be in place before the end of 2018. By then, the project will see over half a million CIPURSE-based contactless cards introduced without the pain, risk or costs of upgrading to a proprietary solution.

Open standards enable flexibility to scale up operations simply and cost-effectively. And with interoperability across all sections of the ecosystem, services are safeguarded for the future. Looking longer term, this simple upgrade to the system enables operators to remain flexible when looking to integrate mobile ticketing or account-based ticketing solutions, for example.

Now in operation on more than 500 buses and across 300 terminals, with minimal disruption to passengers and safeguarded investment in legacy hardware, Cuenca is already beginning to reap the benefits of open standards whilst remaining fully open to future advancements.

Open, non-proprietary standards are changing the game. In short, enabling more secure, cost-effective, scalable, and extensible transit fare collection systems that benefit both the transport stakeholders and the end traveller.

WHO IS OSPT ALLIANCE?

The OSPT Alliance is an international association chartered to provide the standard for secure transit ticketing solutions and beyond. It provides industry education, creates workgroup opportunities, and catalyzes the development and adoption of innovative fare collection technologies, applications and services. OSPT Alliance membership is open to technology providers, transit operators, consultants, solution vendors, government agencies, reader and terminal manufacturers, system integrators and other stakeholders in the contactless ecosystem.

Through the work of its members, the Alliance aims to promote CIPURSE implementation worldwide. For additional information, please visit www.osptalliance.org.

Philippe Martineau is President of the OSPT Alliance Board. He is a seasoned international executive who has worked most of his career in the extended Mobile eco-system. His career started with the emergence of the mobile technology in the early '90s where he contributed to GSM standardization, bringing the SIM technology to market. Doing so, he has developed a strong knowledge of the operators' ecosystem through 17 years at Gemplus with roles ranging from R&D engineering, head of the Telecom business unit to VP of Strategy.

He has since contributed to bringing innovative technologies to market such as NFC as Executive Vice President of INSIDE secure NFC Business line. Having worked for both startups and larger enterprise, he has developed an acute sense of business acumen to combine technology understanding with pragmatic go to market strategies. Martineau is now Senior Director of ecosystem Business development in the CTO office of Rambus where his role consists in bridging Rambus core technology with the mobile world. He has also recently been appointed Chairman of the OSPT Alliance with the intent to drive a greater momentum in the definition of Mobility services.