Smart city: ST's connectivity solution for Electric Vehicle

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Abstract

The smart city ecosystem is emerging as a key strategy for a more efficient and sustainable society, by opening the way to a new wave of innovative applications. Among the smart city subsystems and assets, Electric Vehicle Charging is the area that will be affected by new developments in the next few years. ST is well positioned to address this market by providing all devices needed for this application, including the new Broadband Power Line SoC device that incorporates HomePlug GP/AV Modem.

Introduction

The concept of Smart Cities is one of the loadbearing pillars of a more efficient and sustainable future. Today most of the world's population lives in urban centers, and in perspective, this percentage is growing. This growth is contributing significantly to CO_2 emissions into the atmosphere. Making the City "smart" implies the adoption of an urban model that is energy efficient, sustainable, environmentally friendly, and able to improve the quality of life of people who live there. This is one of the emerging strategies for solving the problem of climate change.

The emerging model of Smart City is an ecosystem of innovative technologies, including Smart Public Lighting, Smart Metering, Smart Building, Smart Parking, and E-Mobility. It is important to note that all these technologies require different kinds of connectivity to facilitate the exchange of bidirectional information. ST is able to provide all the connectivity needed to enable these technologies: WiFi, Bluetooth, RFSubGhz, and Power Line Communication, both Narrow-band and Broadband.

In the context of Smart City, electric mobility, both private and public, is one of the applications that will experience a rapid adoption in the near future.

Plug-in electric vehicle and Smart Grid charging scenario

Smart e-mobility has a key role in the Smart City scenario. Sustainable urban mobility necessitates the integration of electric vehicle charging infrastructure into the fabric of Smart City. . As a "flexible" Smart City system component, electric vehicles are expected to support Active Demand Response programs, helping to shift electricity demand to times of high availability of renewable energy and serve as storage for surplus renewable energy.

When talking about Plug-in Electric Vehicle (PEV), we refer to any motor vehicle that can be recharged from an external source of electricity. Plug-in electric vehicles include two different kinds:

- Battery Electric Vehicles (BEVs) also known as all-electric, which derive all power from any external source of electricity and thus have no internal combustion engine;
- Plug-in hybrid vehicles (PHEVs) where both a conventional internal combustion engine propulsion system and an electric propulsion system co-exist in the vehicle.

To solve the problem of controlling electric vehicles' charging, a communication protocol between the Electric Vehicle (EV) and the Electric Vehicle Supply Equipment (EVSE) is required. A signaling protocol using a Pulse Width Modulation (PWM) signal over the control pilot line of the charging cable has been designed so that

- supply equipment detects the plug-in electric vehicle (PEV)
- supply equipment indicates to the PEV its readiness to supply energy
- PEV ventilation requirements are determined
- supply equipment current capacity is provided to the PEV

This technical specification was described first in the 2001 version of SAE J1772 and subsequently the IEC 61851.
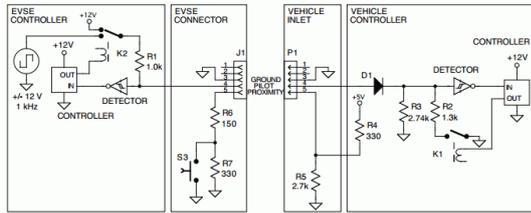

Fig.1 J1772 signaling circuit

According to IEC 61851-1, the EVSE signals its maximum charging power being available by adapting the PWM duty cycle while the EV signals four different states changing the voltage value, as described in the following figure:
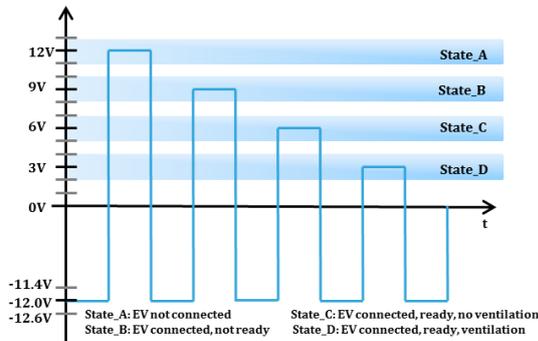

Fig. 2 IEC 61851 EV states with PWM signal

However, a real Smart Grid scenario requires additional and complex digital communication for grid compatibility and management of the rapid charging process. Such digital communication is currently being specified as part of the Vehicle-to-Grid Communication Interface (V2GCI) in the ISO/IEC 15118 joint working group. In this context related to conductive charging, Power Line Communication (PLC) is the chosen ISO/OSI layer 1 and 2 technology being applied on the control pilot line of the charging cable.

The IEEE P1901 (HomePlug AV/GP) is the standard for broadband over power line (BPL), and it has been selected as IP-based power line communication between the vehicle, off-board charging station and the smart grid. The HomePlug® Green PHY (GP) Specification is the powerline profile designed to satisfy the specific requirements of Smart Grid applications, supporting

Vehicle-to-Grid communication, while interoperating with HomePlug AV products and the IEEE 1901 standard. It was developed in cooperation with major utilities with the goal of dramatically reducing power consumption and cost.

Fig. 3 Typical EV integration inside SmartHome

HomePlug GP can be considered as a trimmed down, low power and low data rate version of HomePlug AV, easily allowing multiple silicon suppliers to produce Green PHY chips with relative ease and speed. Backwards interoperability allows use of current HomePlug AV chips to deploy prototypes and early implementations now.

In this context, STMicroelectronics provides the ST2100 STreamPlug, System-on-Chip (SoC) as ST's new device targeting smart-home and smart-energy applications for the world market. It perfectly matches V2GI communication requirements, supporting HomePlug Green PHY, and enabling Vehicle-to-Grid application and Active Demand Response scenario.

ST2100 STreamPlug Overview

The StreamPlug, ST2100, combines a high-performance processing subsystem with Broadband Powerline Communication (PLC). It also includes security accelerators and a wide range of standard peripherals. The ST2100 is designed to support IEEE 1905.1 and therefore enables customers to converge Ethernet, Wi-Fi® and other networking standards in unique gateway or hub. The ST2100 StreamPlug supports popular PLC protocols such as HomePlug® AV and HomePlug Green PHY, as well as IEEE 1901 Broadband Powerline connectivity.

The ST2100 STreamPlug SoC application processor is ARM926EJ-S core based, operating at 330MHz, and provides an external memory-management subsystem. Moreover, this SoC integrates on-chip USB2.0, Ethernet

interfaces, a color-LCD controller, and a CRYPTO HW engine for security algorithms such as AES, DES/3DES and IPSec.

The STreamPlug ST2100 is available in a 12mm x 12mm TFBGA 373 package.

From a software point of view, the virtual machine supports the hosting of guest operating systems, such as Linux Kernel 2.6. Support for PLC protocols includes the latest IEEE 1901 Broadband Powerline (BPL) standard, as well as popular HomePlug standards such as 200Mbps HomePlug AV for carrying HDTV and VoIP traffic and HomePlug Green PHY optimized for smart-grid applications.

Such hardware and software architectures make the STreamPlug ST2100, the Smart HomePlug System-on-Chip, an "Internet of Things" key enabler for smart home and smart grid applications.

ST2100 STreamPlug Modules

ST's collaboration with Tatung to leverage the ST2100 STreamPlug SoC has yielded innovations such as Tatung's Gateway One home-networking hub and other smart-energy devices. The Gateway One enables users to set up multi-bearer home networks combining Ethernet, WLAN, PLC and multimedia devices, thereby greatly enhancing opportunities to improve energy efficiency, security, comfort and convenience throughout the home. Tatung's Meter Bridge and Home-Area Network (HAN) Bridge enable multi-occupancy dwellings to benefit from smart-energy applications, while solving consumption and billing challenges. It is especially important to highlight the M1i and M3 modules developed to serve OEM markets. These modules are designed to shorten the time to market for developers and manufacturers of intelligent devices that provide energy management as well as network connectivity for devices plugged into the AC lines. The M1i is optimized for industrial applications, while the M3 is targeted for the use in Smart Homes and building including applications related to the charging of plug-in electric vehicles.

M1i Module

Industrial temperature range

Modular approach:

- Small size / footprint
- Integrated subsystem – layout optimized
- Critical PLC subsystem layout done on module

Integrated application processor, AFE & HomePlug AV/GP in a single SoC

Rich set of interfaces

Targeted to a wide range of applications:

- IoT & M2M bridging
- Home/building/factory automation
- Energy management
- Intelligent LED lighting
- EV & EVSE

The module supports the following interfaces on the expansion header:

- HomePlug AV/GP (PLC)
- Ethernet
- USB (host or device)
- FSMC (multifunctional parallel 8-bit interface)
- GPIO (up to 24 available w/ PWM support)
- PGC (IR code support)
- SPORT (high speed serial DSP interface)
- TS (video/image sensor interface)
- DAI (I2S audio interface for audio DAC/ADC)
- SPI (3, 4 wire serial control interface)
- UART (2 available)
- FIrDA (optical)
- I2C (industry standard 2-wire serial interface)
- CAN (serial interface based on automotive protocol – 2 available)

M3 Module

The M3 Module is configurable for wide ranges of powerline applications in Home Area Networking (HAN), industrial networking, and smart grid including:

- IoT & M2M bridging
- Home/office/factory/building/city automation
- Energy management

- Intelligent LED lighting control
- Electric vehicle supply equipment (EVSE).
- Audio/video distribution & video surveillance
- Display panel control

The M3 Module is optimized for PLC systems with a large amount of NAND Flash for applications and file system, and supports a wide variety of interfaces on expansion headers:

- HomePlug AV/GP (PLC)
- Ethernet
- USB (host or device)
- FSMC (multifunctional parallel 8-bit interface)
- GPIO (up to 24 available w/ PWM support)
- PGC (IR code support)
- SPORT (high speed serial DSP interface)
- TS (video/image sensor interface)
- DAI (I2S audio interface for audio DAC/ADC)
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M1i and M3 Firmware

The STreamPlug software is comprised of three major components: the ST interface layer with core scheduler, the ST system software, and the Linux kernel over the hypervisor developed by Open Kernel Labs.

The ST interface layer with the core scheduler provides the necessary APIs to support the system software layer and the hypervisor. Then the ST system software provides the core software which implements the HomePlug AV/1901/GP MAC as well the supporting modules. The Linux kernal consists of a collection of Linux (2.6.35.0) device drivers that control the specific hardware interfaces available on the STreamPlug SoC and the hardware platform into which it is incorporated. Using OKL technology to host a Linux guest OS offers several benefits.

- Linux applications can run on the same processor side-by-side with legacy applications and legacy OSes.
- Concurrent support for two OS environments eliminates the need for either multiprocessor hardware or porting the legacy system to the Linux OS.
- Through Secure HyperCell(tm) Technology, OKL4 native cells can complement the Linux virtual machine (VM) by providing an execution environment with better real-time properties and stronger security.
- OKL4 cells are well-suited to hosting real-time OSes, easing implementation of latency-sensitive functions without sacrificing the rich ecosystem support available for Linux.

This robust and flexible software platform is an ideal environment that can host 3rd party application-specific protocol stacks and applications. The platform offers enough processing power to run OpenADR, ISO/IEC 15118, OCCP, and other software components that create a cost-effective and compact single chip implementation of an EVSE.

Conclusion

STMicroelectronics is the ideal partner providing innovative technologies to final customer to create innovative solutions in the entire Smart Grid and Internet of Everything scenario for end-user life augmented experiences.