

UNLEASHING THE FULL POTENTIAL OF THE PRIME PLC STANDARD

PRIME (PowerLine Intelligent Metering Evolution) defines an open, royalty free and non-proprietary standard for the only commercially available, mass-deployed OFDM-PLC technology that ensures true interoperability among equipment and systems from over 25 different certified manufacturers.

The features and capabilities of the PRIME specification have been developed to address the evolving challenges of powerline communications where systems need to work in harsh environmental conditions. PRIME has emerged as the truly proven open ITU and IEEE standard that enables the vision of the smart grid. PRIME fits into a telecommunications architecture, which supports low and medium voltage smart metering, demand response, integration of renewables and home area networks functionalities - making the electricity networks of the future a reality.



PRIME 1.4 is the evolution of PRIME 1.3 towards smart grid

PRIME v1.4 specifications

Version 1.4 of the PRIME specification represents an extension of version 1.3. The inclusion of new features, such as additional robust modes and a new PHY frame type implies that PRIME v1.4-compliant devices shall be able to support scenarios where they co-exist with legacy PRIME v1.3 meters not implementing these new features.

The backwards compatibility mechanism addresses the situation above. It provides co-existence mechanisms at PHY level, allowing nodes from different PRIME

versions to share the same channel without colliding. At MAC level, as soon as the PRIME base node—the main node that manages a PRIME sub-network—is upgraded to PRIME v1.4, co-existence of nodes of different versions is guaranteed. Moreover, connectivity between PRIME v1.3 'clusters' under severe and exceptional noise conditions can be achieved by means of PRIME v1.4 nodes acting as bridges between clusters. This is the most common use case that will be handled by PRIME v1.4/PRIME v1.3 mixed networks. The PRIME Alliance and its members are committed to protecting any investments with PRIME technology and provides backward compatibility in the evolution of the PRIME specifications.

Robustness improvements

In order to cope with rigorous powerline channel scenarios, which may be found in specific countries and application conditions, additional optional robust transmission modes have been introduced in PRIME v1.4: robust differential BPSK and robust differential QPSK. These modes have been designed to improve the system robustness against both impulsive noises and interfering noises. For this purpose, a new PHY frame type has been introduced. Preamble, header and payload of this PHY frame have been enhanced with repetition coding and additional interleaving.

The forward error correction (FEC) mechanism of the PRIME v1.4 robust transmission mode is now composed of the concatenation of a convolutional code and a repetition code. The PRIME v1.4 repeater block repeats the convolutionally encoded bit sequence associated to an OFDM symbol by a factor of four. Since each repeated sequence is placed on a different OFDM symbol, the time diversity of the system increases with consequent improvement of the resilience to impulsive noise bursts.

Moreover, thanks to a cyclic shift of the repeated sequences, each bit replica is placed on a different frequency giving frequency diversity to the system. This means system performance improvement in case of narrow-band interferers as well as channel notches.

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PRIME v1.4 changes are the result of field experience, and no change has been introduced without extensive measurement campaigns in existing deployments (+15 worldwide), and intensive simulation and verification of technical alternatives. The achieved improvements include reliable communications with signal to noise ratio below 0 dB in the presence of white noise, and performance increase under impulsive noise conditions of double digit (10+) dB.

Throughput increase and band-plan flexibility

The PHY layer of PRIME originally specified OFDM in the CENELEC A-band (42 kHz up to 89 kHz), which is intended for distribution grid operations according to EN 50065-1. The successful adoption of PRIME technology in many CENELEC-adopting countries has created an increasing demand outside Europe, which acted as a driver for the evolution of the specification. PRIME v1.4 extends the system band up to 500 kHz, multiplying the bandwidth

KEY ABBREVIATIONS:

BPSK	Binary Phase-Shift Keying
DQPSK	Differential Quadrature Phase Shift Keying
FCC	Federal Communications Commission
FEC	Forward Error Correction
IEEE	Institute of Electrical and Electronics Engineers
ITU	International Telecommunication Union
MAC	Media Access Control
PHY	PHYsical layer
PLC	Power Line Communications
QPSK	Quadrature Phase Shift Keying



PRIME 1.4 boosts throughput and adapts to new band-plans.

originally available by eight. The use of this extended frequency range is subject to applicable local regulations, e.g. EN 50065-1 in Europe, FCC Part 15 in the US, and ARIB STD-T84 in Japan.

PRIME v1.4 provides extreme high flexibility since the newly available channels can be combined in many different ways, constituting 'bands'. The amount of supported bands and their configuration is called 'band plan' and is managed by the MAC layer. The combination of multiple channels into a band allows PRIME v1.4 to achieve rates ranging from a minimum of 5.4 kbps (one single channel in the most robust mode) to a maximum of 1028.8 kbps (eight channels in the less robust mode). For example, since the typical noise behavior in a standard power line channel favors transmission in higher frequency channels, a possible use case combining the three upper channels (#5, #6 and #7) in DQPSK_CC would provide a raw baud rate of 128 kbps.

Improvements at MAC layer

All PRIME v1.4 improvements come together with MAC layer adaptations.

These adaptations have been introduced to manage the new PHY layer possibilities (increased robustness, band-plan management, etc.). This has been accomplished with the enhancement of the channel access mechanisms, and the fine-tuning of the existing channel quality information exchange.

MAC flexibility has been extended, creating dynamic structures capable of adapting frame formats to the requirements of the different applications and the particularities of the sub-networks' form-factors. The consequence is a decreased channel overhead that reduces the number of control packets.

PRIME v1.4 keeps all the advantages of v1.3, including simplicity to keep technology costs down, a focus on interoperability validated by its certification process (45 products certified across 26 different vendors), and network management centralized at the base node to keep a controlled quality of service.

Field experience

PRIME specification has experienced an important evolution in order to improve

system performance. PRIME v1.4 can be deployed globally, even in the harshest network conditions. PRIME has already been extensively deployed for smart metering applications, and with v1.4 specifications it places itself as a valid alternative for other evolving smart grid applications. Medium voltage scenarios, feeder and phase connectivity identification/mapping for smart meters, low voltage remote-control applications now become a reality with PRIME v1.4.



PRIME 1.4 is the highest penetration high data rate narrowband PLC solution for smart metering.

Conclusions

The PRIME member community is currently developing and testing new features and functionalities going beyond the traditional utility smart metering business. This will unleash a new portfolio of added-value services that strongly improve the business case and fit the requirements of an evolving smart grid network.

While there will always be healthy debate about the specific technologies used in any distribution network, it is the ability to deploy and install successfully that ultimately proves the point. With v1.3 installed smart meters approaching 5 million, PRIME confirms it is a proven technology that performs in large-scale, future-proof smart grid deployments.

Coupled with a mature and strict certification process, PRIME v1.4 opens up new geographic markets and applications, meeting the specific needs of the America's and Asia-Pacific region. In practical terms, PRIME fits most applications worldwide in any smart grid scenario. MI



PRIME 1.4 enables the full range of markets and applications in medium and low voltage grids



ABOUT THE AUTHOR:
Inigo Berganza is the chairman of PRIME Alliance's technical working group. He works as supervisor, telecoms engineering at Iberdrola USA Networks. As a technology expert, he participates to various regulatory and standards groups for the PLC industry including IEEE, ITU, CENELEC and others.

ABOUT THE ORGANISATION:
The PRIME Alliance is an industrial alliance consisting of over 65 active members focused on the creation and deployment of an open, single specification standard for power line communications used in smart metering and smart grid products and services.