Keywords: powerline communication, smart grid, ami, metering, energy, mesh, ofdm, prime, G3-PLC, PLC

APPLICATION NOTE 5409

Mesh Networking Extends a PLC Network to Thousands of Meters

Oct 16, 2012

Abstract: The application note addresses how G3-PLC, a powerline communications protocol approved by the International Telecommunications Union (ITU), enables mesh networking in advanced metering infrastructure (AMI) deployments.

Introduction

Mesh networking overcomes limits in communication. Instead of connecting a network node only to the coordinator node (sometimes called the concentrator), mesh networking connects each node in a network with all other nodes within communication range. Then when a message cannot reach an addressed node directly, other nodes automatically repeat the message until it does reach its destination.

Mesh networking is proving to be a powerful approach for sensor networks like those used in advanced metering infrastructure (AMI). This network efficiently links hundreds and even thousands of sensors over a geographical area. Frequently associated with wireless communications such as a ZigBee® system, mesh networking is now available for powerline communications (PLC) systems in a new International Telecommunications Union® (ITU®) standard referred to as G3-PLC. When applied to AMI networks, mesh networking on PLC enables sensors, in this case electricity meters, to be accessed cost effectively and without connectivity issues from walls and buildings. Mesh networking extends the reach of PLC systems, reducing the number of concentrators required.

Emergence of PLC and Its Limitations

PLC has been used for several decades to periodically read electrical meter usage data and eliminate the expense of manual reads. Based on single- or dual-tone frequency-shift keying (FSK) modulation, these PLC systems connect typically 10 to 20 meters to a concentrator located on the same local power lines so meter data can be collected remotely. With data rates of 2kbps to 15kbps, FSK systems cannot support reliable communication since their low data rate supports limited error correction. Instead, with meter reads occurring as infrequently as once a month, extensive retries are often used in collecting all data in FSK systems.

PLC meter-reading systems have begun saving utilities operating costs. It is thus no surprise that those same utilities have already sought both to reduce deployment costs by extending the network served by each concentrator, and to increase electricity conservation by using "smart" communication to implement a smart grid. However, extending the network using mesh techniques, such as message forwarding, is problematic since retransmissions exponentially increase latency when multiple forwarders are used in the transmission. Further, utilities require two-way communication in minutes between meters and concentrators to support smart grid capabilities, including load response and peak load pricing. Consequently, without communications improvements, FSK PLC systems would need to reduce meters per concentrator in an effort to increase response time and effective data rate.

G3-PLC Increases Data Rates and System Reliability

To address this PLC challenge, Maxim Integrated partnered with Electricité Réseau Distribution France (ERDF) and Sagemcom to develop the G3-PLC™ protocol. In January of 2012, the G3-PLC protocol was approved by the ITU as a new low-frequency, orthogonal frequency division multiplexing (OFDM)-based, narrowband powerline communications (NB-PLC) standard. The G3-PLC system uses OFDM techniques to dramatically increase data rates over power lines and increase reliability by interleaving data across frequency and time. Noise immunity is increased further by using two layers of forward error correction (FEC). Even with the overhead of the FEC, G3-PLC delivers up to 250kbps, thereby enabling frequent two-way messages.

Although power distribution grids are electrically a single network, achieving a single PLC network on power lines is limited by attenuation and noise. Attenuation of the power line and power equipment such as transformers, capacitor banks, and power monitors decreases the strength of the PLC signal. This attenuated signal can then have difficulties reaching all meters, especially since meters are placed close to noise sources like home appliances or commercial machines.

To overcome the limits of attenuation, mesh networking is used in the G3-PLC standard to maintain a sufficient signal level. With mesh networking capability in every meter, messages can be forwarded from meter to meter to reach their destination; no additional concentrators which connect directly to each meter are needed. G3-PLC modems automatically form a network and establish routing tables to connect the concentrator with all meters. In this case, when a message cannot travel from the originator to the receipt directly, G3-PLC modems will receive the message automatically and then forward it to the next modem or end destination.

Consider an example. A concentrator sends a message to a meter directing it to delay the start of a water heater to reduce peak loading. The message is attenuated by a MV to LV transformer. Noise from a high-power inverter that has been switched on in the home stops the destination meter, which previously connected directly with the concentrator, from receiving the message. Recognizing that the message is not received, the G3-PLC mesh system uses a nearby meter to forward the message, boosting it to full signal power so it reaches the destination meter.

Forwarding of messages can continue to reach all meters across an electrical distribution network. The size of the network is then only limited by the communications requirements of the smart grid implementation, including end-to-end latency and the data rate to each meter.

Summary

By using G3-PLC technology with built-in mesh networking, the size of a PLC networks is expended to hundreds and even thousands of meters. Deployment costs are dramatically reduced. At the same time, the network is made more reliable because it adapts to changing conditions and adds forwarders, as needed, to reach all meters.

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MAX2992	G3-PLC MAC/PHY Powerline Transceiver	Free Samples

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