ROBUST PLC DESIGNS FOR NOISY ENVIRONMENTS

Designing a new NB-PLC (narrowband power line communications) product is a daunting task for most engineers. Firstly, there are many protocols to choose from, a variety of competitive suppliers and solutions and different end application requirements.

This article will be looking at the challenges facing the product designer, from protocol selection to product implementation, concentrating on the noise issues and how these are handled by all the parties involved for a better performing product.

The power line channel is a very harsh and noisy environment for communications. It suffers from signal attenuation, reflections, interferences, varying impedances and loads. All equipment and appliances connected to the grid have different behaviours and result in different types of noise which have complicated spectral characteristics and exhibits time-varying behaviour. The noise in NB-PLC is generally classified into two categories. First the background noise including Gaussian noise and time-variant or invariant noise. This type of noise is continuous and changes slowly with time. The second is impulsive noise including periodic or random noise. This noise can be periodic or cyclic and it can be either synchronous or asynchronous to the mains frequency. On top of all this, we also find the presence of wireless interference from broadcast stations and other sources.

When it comes to NB-PLC protocols, there are many to choose from, some proprietary and others that have been standardised. In Europe, PRIME is one of the main standards used by metering utilities with over 20 million smart meters installed worldwide. Metering is not the only application of these standards, there are many others like lighting or home automation. Renesas offers a single PLC modem (R9A06G037) which can support all NB-PLC based protocols with a simple change of software. Alliances are working continuously as the rollout progresses and more knowledge is gained to improve the standards. Robust modes have been introduced for better communication performance at the expense of lower data rates.

Renesas has worked very closely with major European utilities to understand the challenges faced and collected valuable data from the field to analyse and understand the real-world environment. A typical sketch of the noise obtained from the field recorded data is shown in Fig 1.

The recorded signal can be further studied and analysed using techniques like cyclic spectral analysis, impulsive noise detection and reduction, and adaptive bit loading to understand the different components of noise affecting the NB-PLC signal and build a robust and better performing DSP PHY to countermeasure most types of noise. Renesas has experimented with many established techniques and evaluated their performance. Among the mechanisms used, there are blanking, blanking with fixed threshold, adaptive bit loading, weighting,

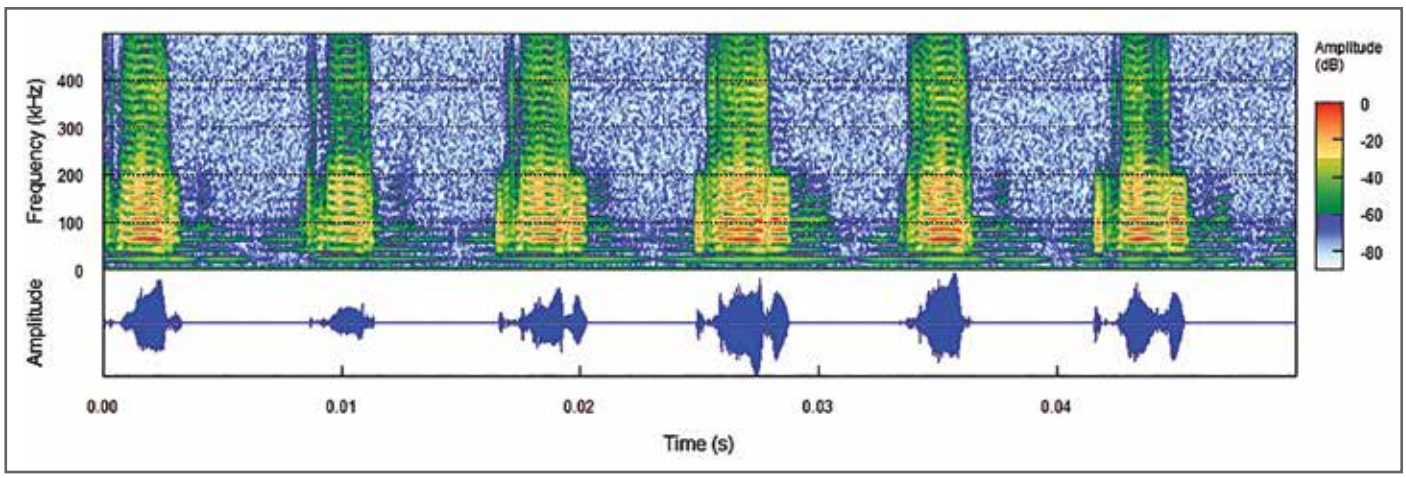

Figure 1: Recorded signal and its frequency spectrum

Figure 2: Renesas NB-PLC Laboratory

weighting with tone mask and weighting with synchroniser detection to name a few. With these improvements, Renesas offers one of the best performing PHY in the market according to utilities.

Renesas has also invested in an extensive lab facility (Fig 2) which can accommodate nearly 1000 nodes running any NB-PLC protocol. The lab can be used to monitor and analyse the network and work on improving the stack performance. It is possible to insert power cables and attenuators between different areas and insert noise at any point in the network. This gives a very good simulation of the real world.

Once the protocol is chosen, and the chipset is available the responsibility lies totally in the developer's hands. To make a product with good immunity to noise, care must be given to the power supply and the PCB design of the board.

The device's power supply is commonly acknowledged to be a major noise source to all systems and when dealing with NB-PLC. Care must be taken in the design not to induce noise from the power supply to the system. The NB-PLC signal bandwidth ranging from 35Khz to 500Khz can be disturbed by the harmonic's components of the switching frequency of the converter when using a switched-mode power supply for the AC-DC domain. It is, therefore, preferable to use a switching operation frequency of 1MHz or above. The same applies to the DC-DC converter stage and it is preferable to use pulse with modulation (PWM) with a fixed operation frequency to control the noise component. When using other methods like pulse frequency modulation (PFM) and pulse skip modulation (PSM) extra care should be taken not to affect the NB-PLC characteristics.

An NB-PLC board needs to be treated as a mixed-signal design containing both high and low voltages. The key to the optimum board layout is understanding the current return path to ground and making these with minimum impedance and minimising the current loop. In a typical NB-PLC system, the signal is fed through the coupler, via the Analogue Front End (AFE) circuit to the modem. Circuitry placement is very crucial and certain considerations are very critical to achieve the optimum performance. The rule of thumb is to arrange the parts following the NB-PLC signal and keep the signal wiring as short as possible to avoid flux coupling and wrapping effects. To keep the noise from the power supply at bay it is necessary to allow enough distance to separate the power supply circuits generating noises from the AFE circuit and the modem signal path. Separating the AC-DC GND from the modem's grounds is also recommended, and whenever possible to fill the unused area in the PCB layout with GND patterns to enhance the GND. Other points to watch out for are the signal separation and noise shielding layers including VCC and GND. The AFE and the modem will generate a great amount of heat and it is necessary to allow this heat to be dissipated somewhere. To achieve the above-stated requirement possible, it is best achieved using a PCB substrate with four layers or more.

Renesas offers the know-how and the expertise in the NB-PLC technology to its customers by offering a large collection of reference designs, application notes, webinars and a wide range of testing equipment in the NB-PLC lab to support the customer during all the steps of the design from schematic to certification. Also, Renesas supports its customer by providing the option to review the schematic and PCB design before prototyping. This ensures all the requirements and recommendations are met, and the design implements all the noise countermeasures for a product with better performance. SEI

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Lahcin Ait Aissa is a systems application engineer with more than 15 years of experience on connectivity technologies and related protocols. Today his focus is on NB-PLC solutions in the smart energy and smart home area. Lahcin brings his knowledge and expertise into the standard's Alliances where he is very active.

ABOUT THE COMPANY:

Renesas Electronics provides smart solutions to enable billions of connected and intelligent devices. They deliver a broad range of leading-edge semiconductor technologies with comprehensive solutions for automotive, industrial, home electronics, office automation and information communication technology applications. Renesas is a member of the PRIME Alliance