ST8500 – Power Line Communication Package for PLC non-metering applications
The ST leadership in smart grid

ST technology solutions covering all smart grid applications building blocks

30 Years Experience in Smart Grid with key Utilities, Manufacturers, Industrial Alliances and Standardization Bodies

+130 million smart meters with ST inside

Field-proven, integrated, performing flexible and future-proof
Smart Grid – Product Roadmap

**Connectivity**
- ST7580
  - N-PSK transceiver
  - Prot agnostic
- ST75MM
  - BPSK transceiver
  - Meters & More
- ST8500
  - Multii-PLC protocols
  - Prorammable OFDM DSP
  - 500kHz band
  - Security engine
- STLD1
  - Power Line Driver

**Metering**
- STPM32, 33, 34
  - 2 ch, 3ch, 4ch 24-bit Sigma Delta ADC
  - DSP energy calculator
- STCOMET10
  - 3-ch 24-bit Sigma + DSP
  - PRIME/G3 protocols
  - M4 app core + Flash
- STPMS2 + STISO621
  - 2x 2nd order 24-bit SD
  - 6kV Galvanic isolated digital I/F (STISO621) + shunts
  - STM32 turn-key FW processing

**New, proto availables**
- S2-LP
  - Sub-1 GHz RF
  - Low Power

**Hybrid PLC-RF Solution**
# PLC Frequency Bands Regulation

## EUROPEAN REGULATION CENELEc EN 50065-1

<table>
<thead>
<tr>
<th>f (kHz)</th>
<th>NO REGULATION</th>
<th>ALARM and SECURITY systems</th>
<th>DOMESTIC networks with CSMA</th>
<th>INDUS/CONSUMERS, no collision management</th>
<th>ELECTRICITY SUPPLIERS</th>
<th>ELECTRICITY SUPPLIERS</th>
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<tbody>
<tr>
<td>500</td>
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</table>
Agenda

- ST and PLC
- ST8500 platform description
- ST8500 package for non-metering applications
- Deliverables & reference designs
- Hybrid PLC & RF Connectivity
Programmable, ultra-low power and compact PLC solution

- Fully programmable, high performance
  400 MHz DSP and 200 MHz ARM® 32-bit Cortex®-M4F core, 360kB RAM
- Ultra-low power consumption
  <100 mW in Receive mode
- Embedded AES cryptography engine
  up to 256-bit key and multi-security modes
- Multi-standards, full 500 kHz bandwidth
  support any band: CENELEC, and FCC
- Extended temperature range
  -40°C to 105°C
- Small footprint package
  QFN56 7mm×xmm
ST8500 Application Block Diagram

**ST8500**
- Reprogrammable Power Line Modem
- Integrated Analog Front-End (0 – 500 kHz)
- Full duplex interface via UART
- Security: OTP, AES 128-256 with (GCM; CCM; ECB…)

**STM32 Host MCU**
- Store FW images in eFlash or external SPI Flash
- Download image to ST8500 & drive modem
- Manage customer FW application

**STLD1 – Line Driver**
- Dual line driver 18 V p-p single ended, 36 V p-p differential output range
- Up to 1.5 A RMS driving capability
- Thermal and Current feedback

VIPER26HD
Power supply

LINE
NEUTRAL

15V
3.3V

AC mains Connector

Line Coupling + STLD1

ST8500

STM32 HOST
## ST8500 PLC Stacks

Multi Standard Power Line Platform

<table>
<thead>
<tr>
<th>Protocols</th>
<th>CENELEC A</th>
<th>CENELEC B</th>
<th>FCC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G3-PLC Alliance</strong></td>
<td>Unique HW/FW for <strong>Device node &amp; PAN Coordinator</strong></td>
<td><strong>G3 certification</strong> in Cenelec A, B and FCC band</td>
<td></td>
</tr>
<tr>
<td><strong>PRIME Alliance</strong></td>
<td>1 FW for Service Node / 1 FW for Base Node</td>
<td><strong>Certifications:</strong></td>
<td></td>
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<td></td>
<td></td>
<td>PRIME 1.3.6 (CenA)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>PRIME 1.4 : channel 1 (CenA) / ch 2 (Cen BCD) / ch 3 to 8 (FCC)</td>
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</table>
ST PLC FW Partitioning

ST8500 based solutions

- NOT ST
- ST

STM32
- DLMS/COSEM
- Host interface
- PRIME CL 4-32
- PRIME MAC RT
- PRIME PHY (OFDM)

ST8500
- DLMS/COSEM
- UDP
- IPV6
- Host interface
- 6LowPAN
- MAC
- G3 PHY (OFDM)

(Service node)
ST8500 : Host / modem G3-PLC FW partitioning

- Cortex and RTE Images (350kB) can be stored in *
  - SPI Flash connected to ST8500
  - SPI Flash connected to STM32
  - directly in HOST eFlash

- Image download from STM32 UART to ST8500
  - Download using USART @ 920kbps
    ✓ 5sec for typical application

- ST8500 starts in ADP (6LoWPAN) mode
  - configured by the Host (UART msg)

- Flexible UDP/IP and bootstrap:
  - on STM32 side
  - on ST8500 side
## ST8500 standard G3 package Pros & Uses

**Narrow band power-line communication platform**

### Advantages

<table>
<thead>
<tr>
<th>Benefit from intensive G3/Linky validation</th>
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<tbody>
<tr>
<td>Turn-key communication stack (G3 based) included</td>
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<tr>
<td>Fully programmable platform</td>
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<tr>
<td>HW AES up to 256 bit encryption service</td>
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### Typical Uses

<table>
<thead>
<tr>
<th><strong>Typical user DR in range of 10-20Kbits/s</strong></th>
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<tbody>
<tr>
<td>200kb/s max data rate (PHY level)</td>
</tr>
<tr>
<td>Mesh Network topology</td>
</tr>
<tr>
<td><strong>All protocol and network features embedded</strong></td>
</tr>
<tr>
<td>(code to be stored on external Flash or MCU)</td>
</tr>
<tr>
<td>Typical up to 1000 nodes</td>
</tr>
</tbody>
</table>
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ST and PLC

ST8500 platform description

ST8500 package for non-metering applications

Deliverables & reference designs

Hybrid PLC & RF Connectivity
PLC used for elevator system control

- The customer application is dedicated for elevator functions (call button, floor selection, alarm, ..)
- The modem will transmit the commands through the mains
- The commands will be received by the “motor control” application
- The modem can also receive broadcast information from the central system (remote monitoring, alarm, …)

The bootstrap protocol (discovery, individual addressing, etc..) is autonomously proceeded by Modem boxes
MESH networks, PLC used for a city’s lighting control

- A very simple application runs on each street lamp.
- The central lighting control will command each lamp independently.
- Each lamp can also inform the central for remote maintenance.

G3 communication has been validated over several kms distance and in noisy conditions.
A similar system can be used to connect stations for air quality, security and traffic.
Demo setup

- The partitioning of demo as follows:
  - 2 evalkits ST8500 (minimum) connected to the AC grids (or a DC bus 20V to 60V) and to the laptop
  - The user’s laptop running the SmartGrid Labtool GUI (1 instance for each node)
ST8500 “open market”: FW package overview

ST8500 for industrial applications

Figure 1. Static architecture view
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- Deliverables & reference designs
- Hybrid PLC & RF Connectivity
• It can be downloaded from ST web site:
  - Tools & Software
  - Embedded Software

• “STSW-SGTKITGUI” : GUI for PC
  (=SmartGrid_LabTool)

• “STSW-ST8500G3” is composed of:
  • G3 PLC images for ST8500 (binaries)
  • STM32 FW: .dfu and source code, including IAR project
Some documents are also proposed:

- AN5336: ST8500 host interface driver
  - Overview of Host Interface for FW download and for G3 protocol interaction

  - FW architecture overview
  - Description of STM32 application FW example
The original kit is made of three boards:

1. The ST8500 PLC module including the companion STLD1 line driver
   *Designed for AC grid – Compatible with DC bus*
2. The STM32 mother board
   Connectors for FW upgrade, GUI connection and FW debug
3. The AC/DC power supply board based on the VIPER26H
   *This board should be replaced by DCDC board for DC application*

**Reference designs** for AC and DC application are proposed:

1. Differential and single ended design (no Transformer)
2. DCDC power supply design adapted to different network characteristics (voltage, wire length, impedance)
3. More to come… (example application, BOM optimized design, …)
ST8500 Ecosystem

PC Tools
- Graphical User Interface
- FW download
- Small network installation

Evaluation Kit
- Order on st.com
- Schematics, gerbers, user manual
- Testing facilities for debug

HW resources
- Datasheet
- Reference design for AC and DC configuration
- Application notes, tips, guidelines

SW packages
- Open market package
- G3 Firmware deliveries
- Host API driver for STM32 and Linux
- Documentation
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Overcoming limits of a single communication technology

- Higher KPI requirements, challenging network topologies
  - Dual non-integrated technology may not give the best performance
  - The best integration should be done in the lower layers of the communication protocol stack

- Possibility to expand to other Smart Grid services

- Solution: fully hybrid PLC + RF Network
  - Each node has PLC or PLC+RF connectivity to others
    - PLC as preferred channel
    - RF-only can be one option for “leaf” nodes
  - The route is built with a hop-to-hop automatic selection of the “best” between PLC and RF media
  - The media selection is dynamically adjusted based on the media status
First approach on G3-PLC technology
- Already based on IEEE 802.15.4-2007 standard

Layer 1 extension: added FSK RF PHY from 802.15.4-2015/17

Layer 2 integration:
- 2 separate MAC Layers (CSMA, ACK, …)
- Hybrid Abstraction Layer to deal with common lower layer procedures
- Hop-by-hop PLC or RF media selection

The same approach is suitable for other PLC standards
- PRIME Alliance is working on a similar integration, based on the same FSK RF PHY
Hybrid PLC + RF technology: ST turn-key solution

- **Fully modular solution:**
  - Scalable choice of STM32 application host
  - ST8500 as PLC modem and PLC + RF protocol processor
  - S2-LP (RF L1) can be removed for PLC only nodes
  - STLD1 (PLC Line Driver) can be removed for RF only nodes (options for leaf nodes)
Hybrid connectivity for smart infrastructure

IPv6 PLC & RF connectivity for cities, buildings, utilities, industrial & commercial areas

Smart Street Light PLC/RFC
Expandable sensor ecosystem

Environmental & CO₂ sensor
Motion sensors
Microphone arrays

Gateway
PLC/RF

Remote RF sensor

Cloud
Remote control center
ST stands for life. augmented

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