Horizontal vs. Vertical Preamble Detection Comparison

Avi Kliger, Broadcom

PLC Summary

- PLC is centered around a frequency on a well defined grid of 6 MHz spaced frequencies
- Downstream occupies up-to four non-overlapping OFDM Channels , each of 192 MHz wide, with a center frequency that is not necessarily the same as the center frequency of the PLC
- PLC center frequency, FFT size and CP size are not known to a new joining CNU
- Legacy services may appear in-band on the same 6 MHz grid and may occupy a large part of the OFDM Channel

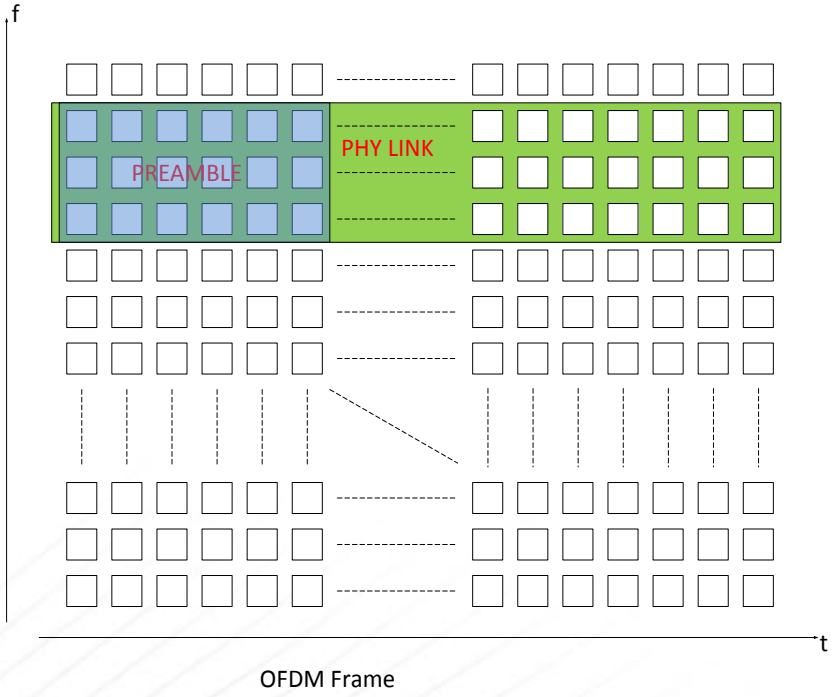
PLC Synchronization Sequence

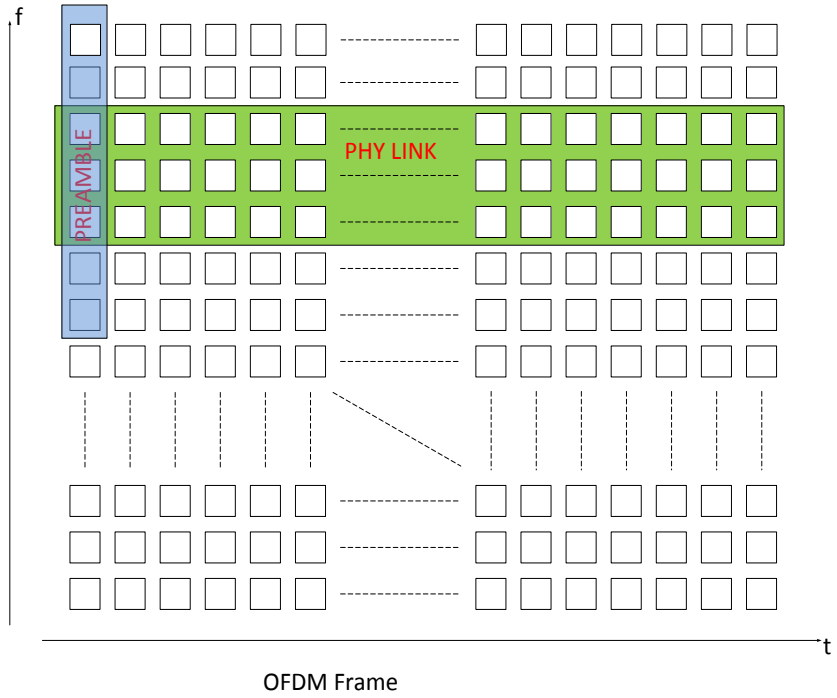
- A synchronization sequence (also called Preamble) is required to identify the start of the PLC frame
- PLC Preamble can be used to detect the PLC channel and to align the receiver with the PLC frame
- The Preamble can reside on one OFDM symbol (referred to as a Vertical Synchronization Sequence, VSS) or it can expand over several OFDM symbols (referred to Horizontal Synchronization Sequence) in this presentation
- In both cases the Preamble occupies several subcarriers in a symbol
- This presentation tries to compare the two Preamble types for EPoC

Downstream receiver tasks at Initialization

- The downstream receiver should be able to detect the PLC channel and decode its data.
- It needs to:
  1. Recover the FFT size, CP size, frequency offset and FFT boundary (trigger point)
  2. Detect the PLC channel by detecting a periodical Preamble
  3. Decode the PLC data
- #1 and #3 are required for both the horizontal and vertical Preamble so are not considered here
  - Several methods exist to detect and recover the FFT size, CP size and frequency offset, both wideband and narrowband, parallel or serial that can be used independently to whether the Preamble is horizontal or vertical

Horizontal and Vertical synchronization Sequences Assumptions (based on Hualwei's contribution)





Horizontal Synchronization:

- Occupies 8 to 32 carriers in frequency
- Occupies 4 to 16 symbols in frame
- Always at the OFDM Frame beginning

Vertical Synchronization:

- Occupies 128 to 256 carriers in frequency
- Occupies 1 symbol in frame
- Always at the OFDM Frame beginning

Required Processing - Comparison

Horizontal Synchronization

1. Find Symbol Timing, coarse CFO, & CP Size
2. Decompose signal into 32 sub-bands, each 6.4 MHz to 1.6 MHz wide
3. Each sub-band can be down-sampled by a factor of 32, Preamble BW is 400 KHz
4. Cross-correlate each band with the reference sequence
5. After the preamble is found, decoded data.

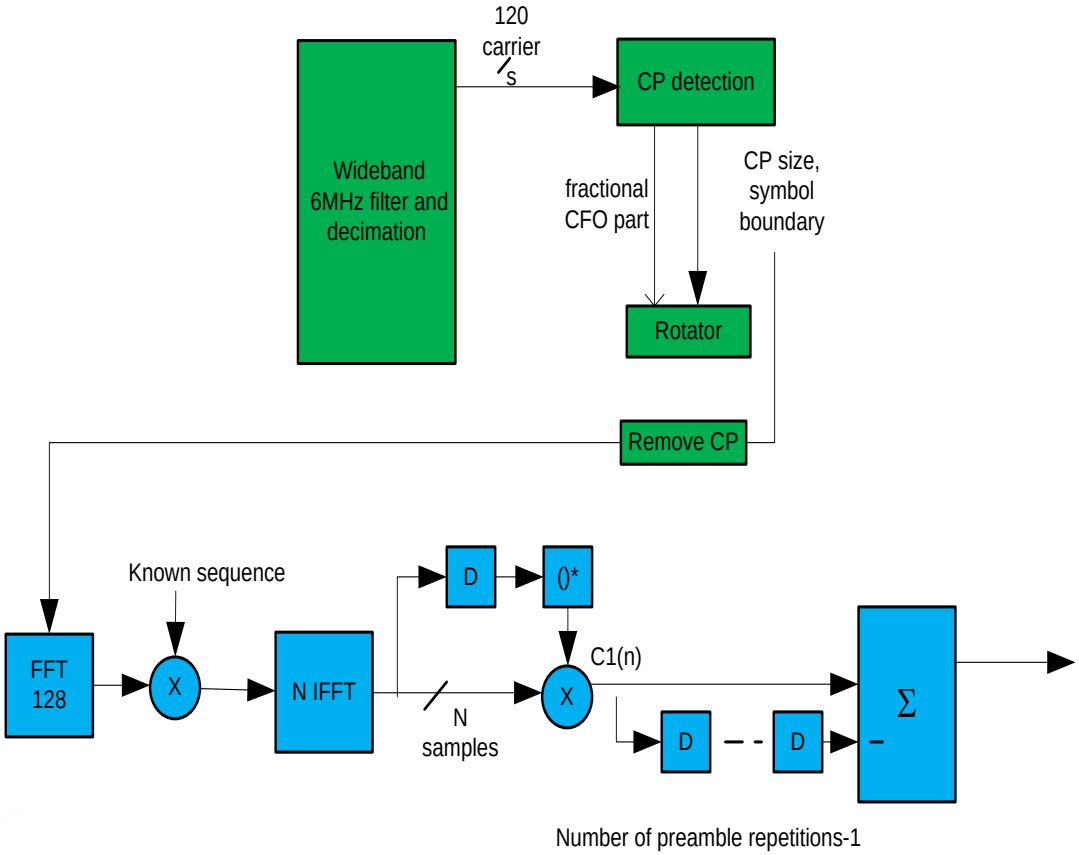
Vertical Synchronization

1. Find Symbol Timing, coarse CFO & CP Size
2. Decompose signal into 32 sub-bands, each 6.4 MHz wide
3. Each sub-band can be down-sampled by a factor of 32, Preamble BW is 64 MHz
4. Cross-correlate each band with the reference sequence
5. After the preamble is found, decode data.

Cross-Correlator for Preamble Detection

- Cross-correlator is implementation dependent,
  1. Remove CP
  2. Perform FFT (NlogN mults)
  3. Multiply the result by the reference sequence (N mults)
  4. Perform IFFT (NlogN mults)
  5. Find maximum (Note that Maximum position and phase convey additional information about CFO and channel delay)

  Total complexity N(2logN+1) multiplications



Sequence	Number of carriers	Number of symbols	Sampling Rate [MHz]	"wasted" data carriers	Complexity (Mult/symbol)	Detection Speed (symbols)
VSS	128	1	6.4	128	1920	1
HSS	8	8	0.4	64	56	8

Note: number refers to 4K FFT

Comparison

VSS		HSS	
Pros	Cons	Pros	Cons
Longer correlation sequence, better correlation properties	Correlation sequence appears only once in the OFDM frame	Correlation result can be averaged over a number of symbols to increase noise immunity	Short correlation sequence
Fast detection (in 1 symbol) BUT detect time limited by Preamble period	Preamble detection is more complex 1920/4352 Multiplications/symbol	Lower complexity Only 56 to 144 Multiplications/symbol	Detection take s 8 symbols.
	More overhead with the same period of premables	Preamble repetitions can be used for CFO/SFO estimation improvement	
	Non complaint with higher layer requirements for PLC	PLC and Preamble structure complies with Higher layer requirements: no jitter, no buffering, transparency to MAC, no reliance on frequency availability beyond 6 MHz	

Summary

- HSS uses longer Preamble in time and shorter in frequency
- VSS uses shorter Preamble in time and longer in frequency
- This makes HSS more suitable for PLC requirements
  - Transparency to MAC
  - No additional jitter and latency
  - No additional buffering
- VSS does not comply with these requirements
- HSS can use smaller cross-Correlator, simpler by 30 times
- Other processing to acquire the PLC are similar in both methods
- HSS takes longer to acquire a Preamble BUT this has no effect in the PLC discovery time which is a function of Preamble spacing
- To achieve same acquisition time, VSS will have more overhead
- To summarize: HSS is better suited for the PLC requirements