

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [ETRI PHY Proposal on VLC TDM for LED Signboard]

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Re: [Response to call for proposals]

Abstract: [This document describes a proposal of PHY TDM for LED signboard]

Purpose: [Proposal to IEEE 802.15.7 VLC TG]

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ETRI Proposal on VLC TDM for LED Signboard

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ETRI

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ETRI PHY Considerations based on TCD

- Target Application
 - VLC using the Illumination at office/home environment
 - White LED & RGB LED
- Considered data rate and range: A1*
 - Infrastructure to mobile
 - High data rate: 1Mbps~
 - Short range: $\leq 3\text{m}$
- Divergence angle of illumination
 - Very various
 - LED fluorescent: $110^\circ \sim 310^\circ$
 - PAR type: $60^\circ \sim 140^\circ$ ($30^\circ \sim 40^\circ$ is possible)

ETRI PHY Scope

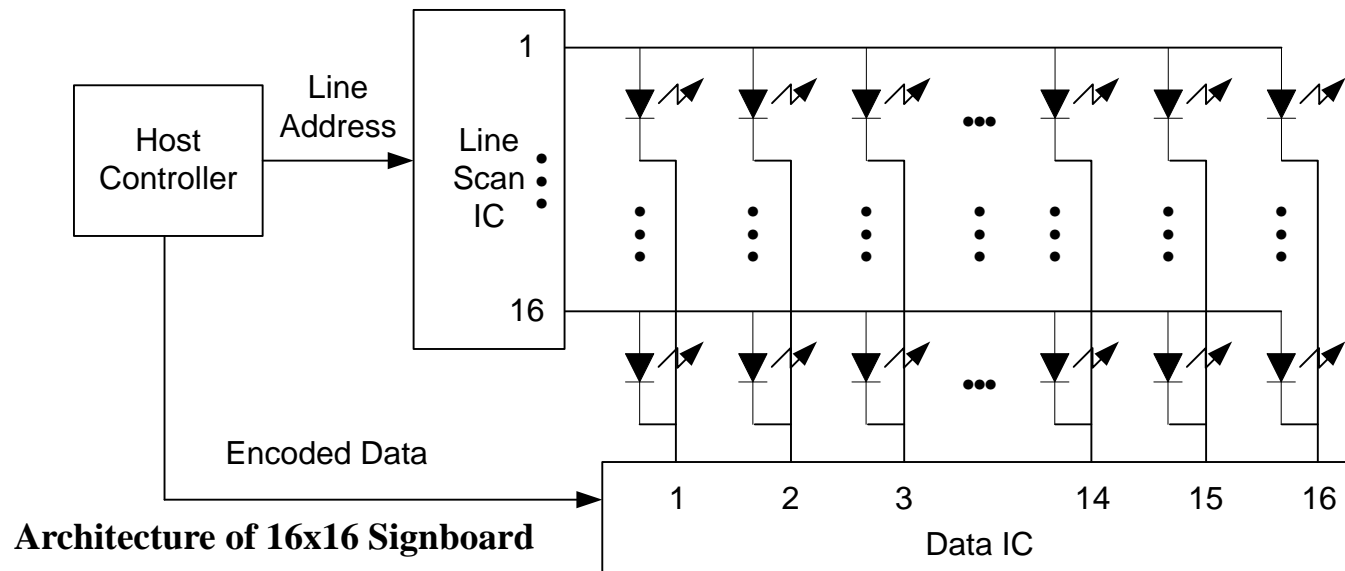
- Office illumination
 - Infrastructure to mobile
- Transmission device
 - white LED (yellow phosphor)
 - R, G, B LED
- Data rate and distance
 - 1Mbps(DL/UL) @2.5m
- Directivity
 - Bi-directional (Full or Half), Uni-directional

ETRI PHY Proposal

- Line code
 - 4B6B
 - Modified-4B5B: M-4B5B
- Modulation
 - Variable Pulse Position Modulation: VPM
 - Reverse-Return to Zero: R-RZ
- Multiplexing
 - Time Division Multiplexing(TDM) for LED signboard

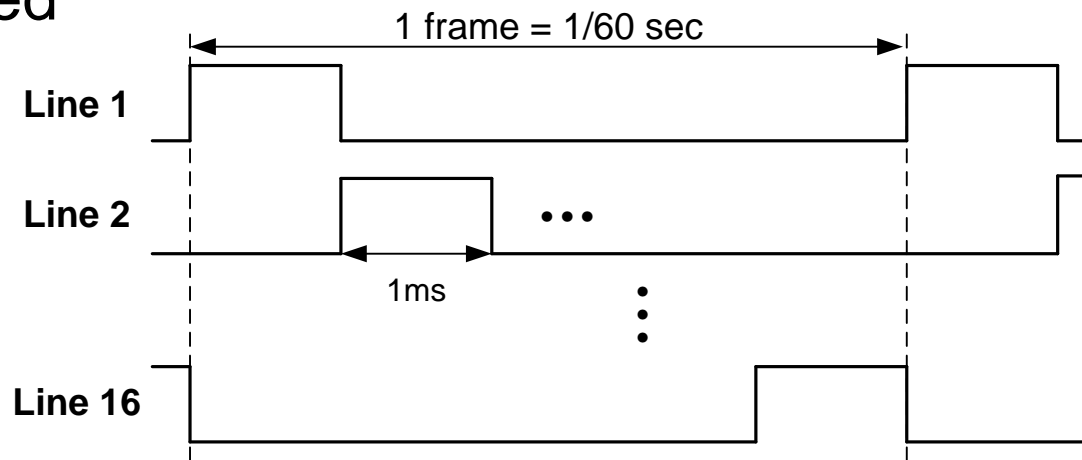
Architecture of general LED signboard

- Line scan : selection of line for data stream, sequentially repeat
 - Active high
 - Determine the operating time of each line
- Data : on/off or color selection information of each dot on the selected line
 - Active low



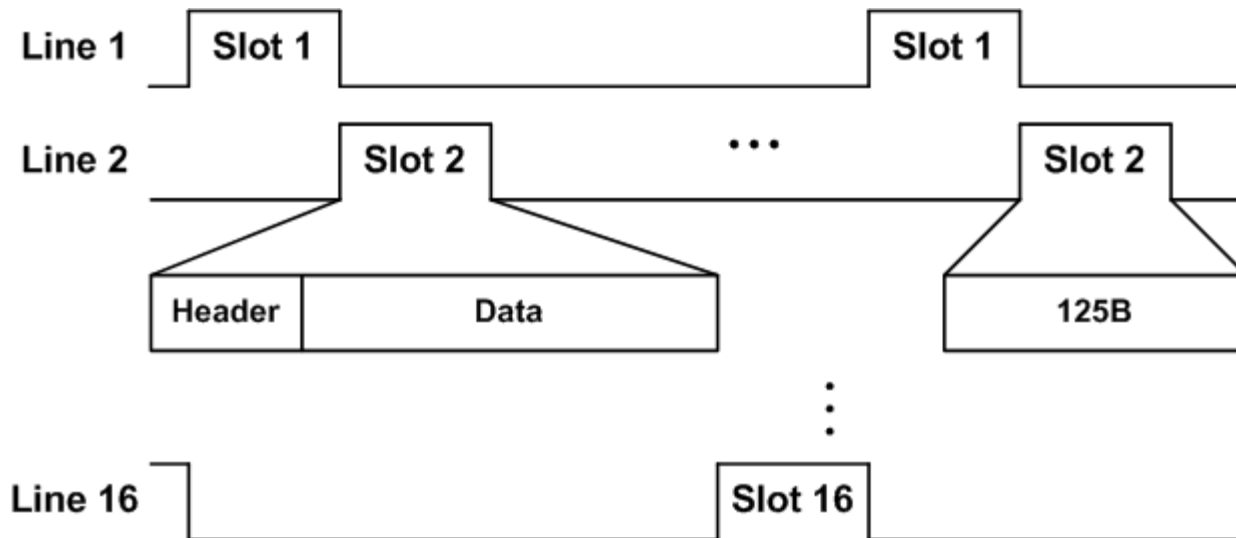
Operation of 16x16 Signboard

- PC Monitor, TV: transmit 60 frames/sec
 - Transmit 30 frames twice
- At 16X16 signboard, 16 Lines have to operate 60 times during 1 second.
 - Operating time for 1 line : $(1\text{s}/60\text{f})/16\text{fpl} \approx 1\text{ms}/16$
 - At the signboard industry, generally 25 to 60 fps is used



TDM for Signboard

- Line operating time = 1ms \rightarrow 1 time slot
 - 16 time slots is possible
- 1Mbps: 1kbits/1ms = 125bytes/1slot

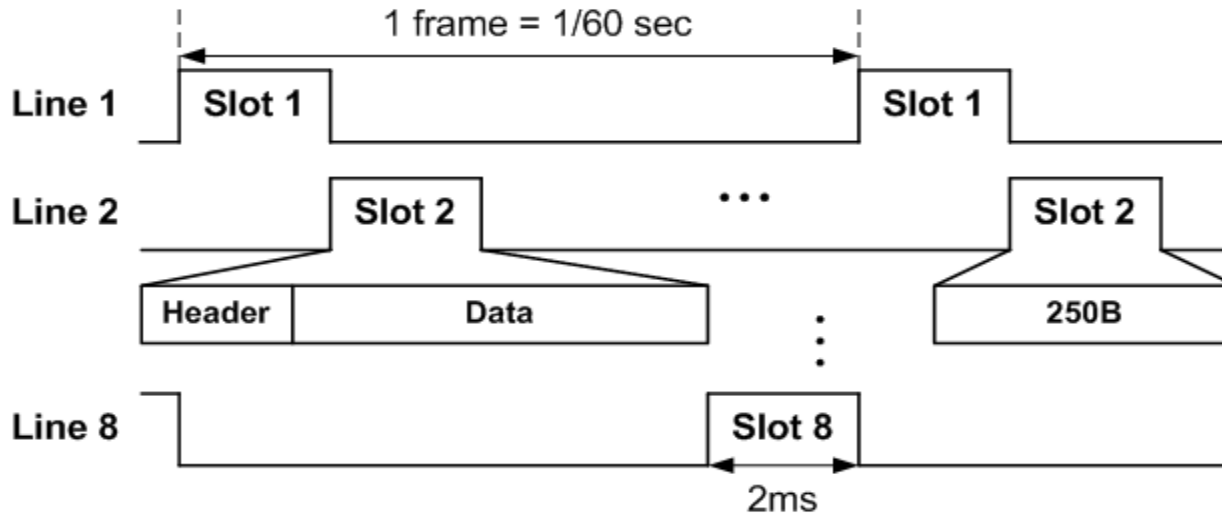


Requirements for VLC at signboard

- Required same brightness at each time slot
 - Required flickering free technology, such as 4B6B line code and Manchester code
- Required same brightness whenever data is transmitted or not.
 - Idle slot modulation
- Required same brightness before VLC is applied
 - Brightness will be reduced to 50% by VLC data stream
 - Need to increase of operating time per line
 - 100% duty of 1ms = 50% duty of 2ms = 1ms on time per second
- Using simple frame structure, increase the link efficiency

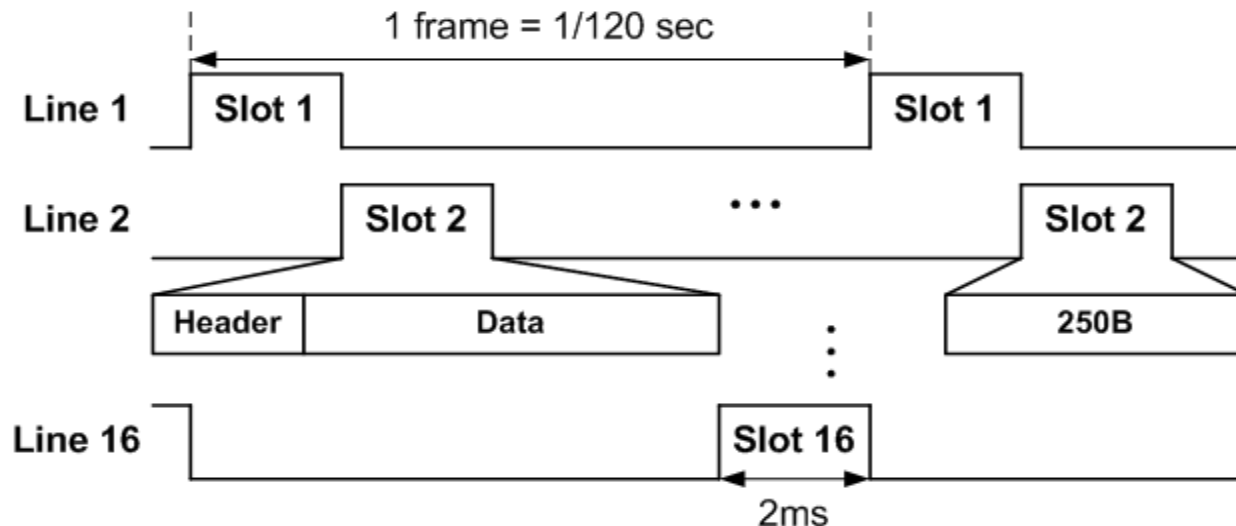
Proposed TDM for Signboard: solution 1

- Increase Line operating time = 2ms/1 time slot
- Reduce time slot
 - 8 time slots
 - Divide to two block of 8x16
- 1Mbps: $2\text{kbits}/2\text{ms} = 250\text{bytes}/1\text{slot}$



Proposed TDM for Signboard: solution 2

- Increase Line operating time = 2ms/1 time slot
- Increase period
 - 16 time slots
 - 30 frames per second
- 1Mbps: $2\text{kbits}/2\text{ms} = 250\text{bytes}/1\text{slot}$



Purpose of Beacon slot

- General purpose of beacon frame
- Is to Inform that the following frame is a TDM time slot
 - Number of time slot
 - Length of time slot
- is to allocate the time slot according to
 - Service
 - User
 - QoS policy by multiple slot allocation according to service level

Time slot structure

- Beacon slot
 - TS0
 - VLC header for compatibility
 - Source address and destination address
 - Length field of beacon slot
 - Service type
 - Information Broadcast service
 - Data download service
 - Time slot information
- Data slot
 - TS1 to end of TS
 - Simple header
 - Destination address (only for data download service)
 - No length field

Expected Applications

- Multiple broadcast service at Food court, department, and so on
 - TS1 (Korean), TS2(Japanese), ... , TS16(information)
 - TS1 (1'st floor), TS2(2'nd floor), ...
- QoS supported membership service
 - Different data download speed by membership level
 - Gold member allocates 3 time slots
 - Silver member allocates 2 time slots
 - Bronze member allocates 1 time slot

Summary of Proposal

- Operating time of each line(LED) on the signboard is fixed
 - Propose TDM
- Propose time slot structure and allocation
- Propose multiple broadcast service and QoS service
- If we use VPM for LED signboard, we can control brightness of signboard.