



**Mohamed Hafed**  
Introspect Technology

**MIPI C-PHY<sup>SM</sup> And How It Enables  
Next Generation Display and  
Camera Implementations**

**2017**  
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DEVELOPERS  
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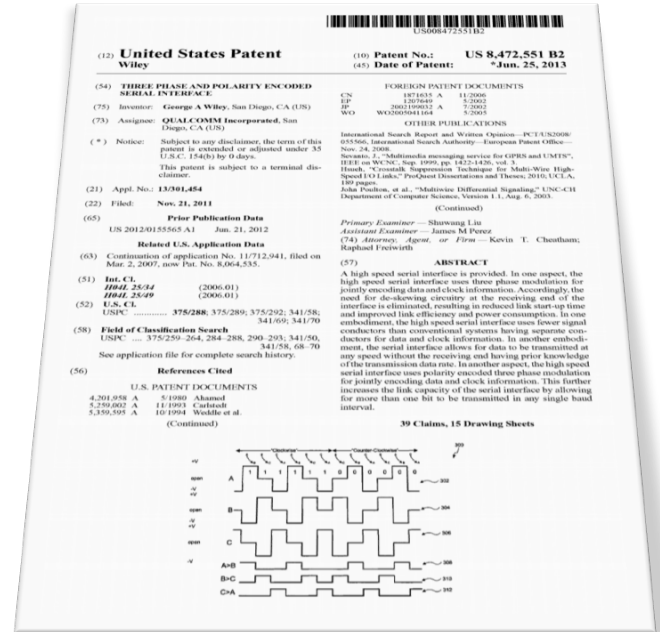
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# Original Spark: Three Phase Encoding!

1 Unit Interval of Data

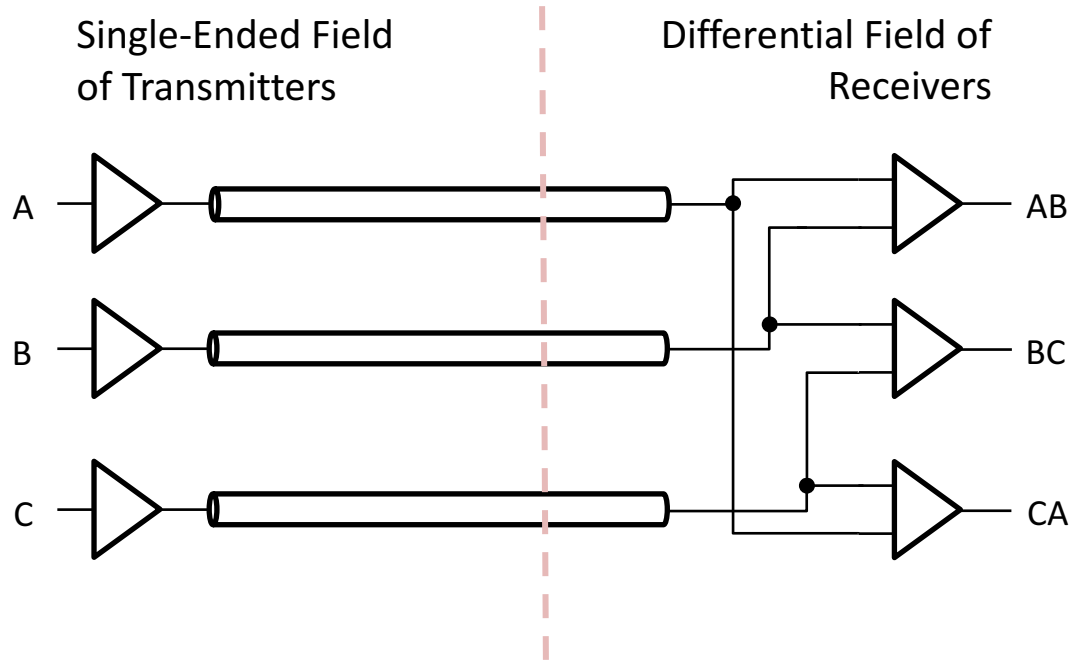


2.285 Bits of Information

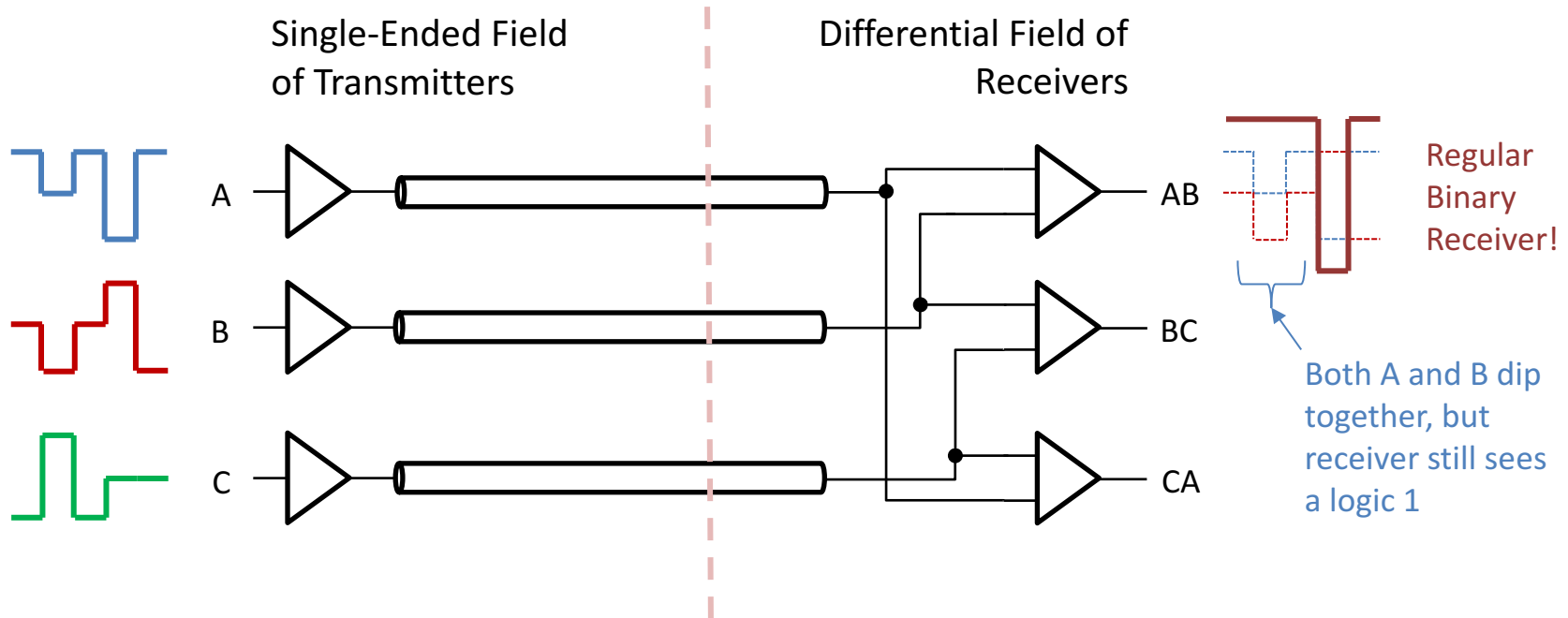


George Wiley, Qualcomm

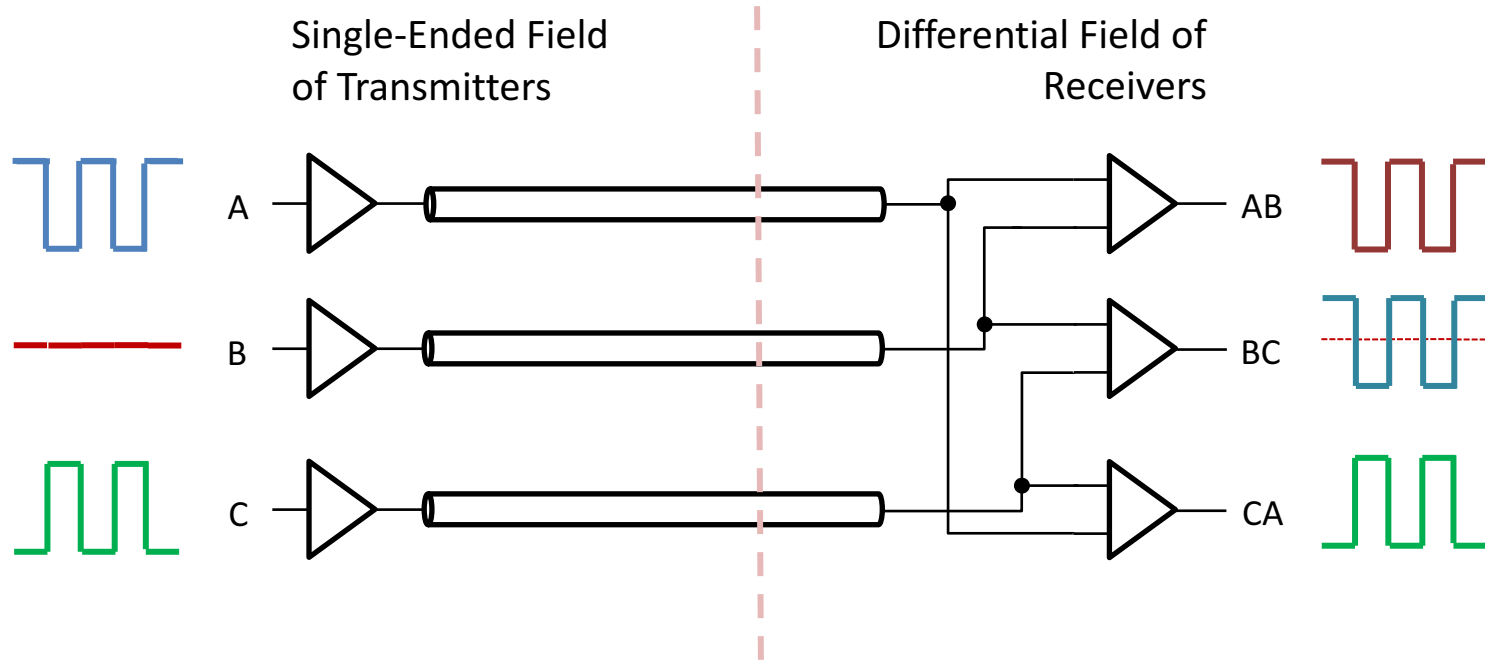
# Basic Concept – One Trio



# Three Voltage Levels Ensure Proper Differential Reception



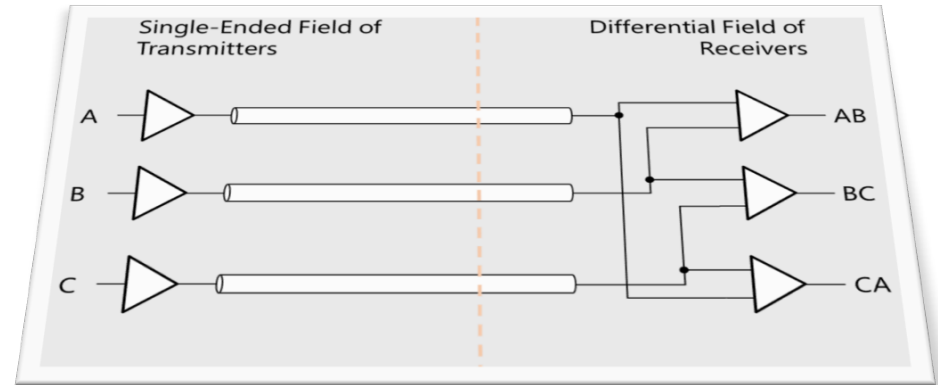
# Always-Toggle Design Allows for Simple Clock Recovery (100% Aggregate Transition Density)



# Key Takeaways

Three-level single-ended signaling

Non-deterministic transitions based on self-clocked mapping and encoding algorithm

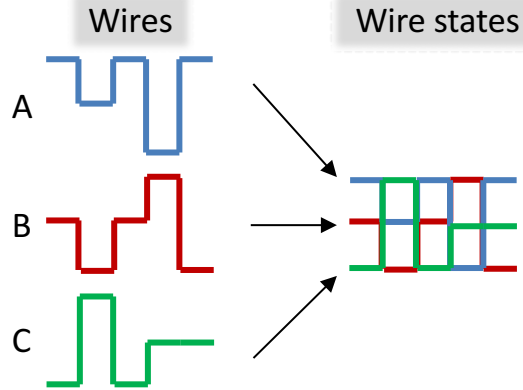


# Encoding and Mapping

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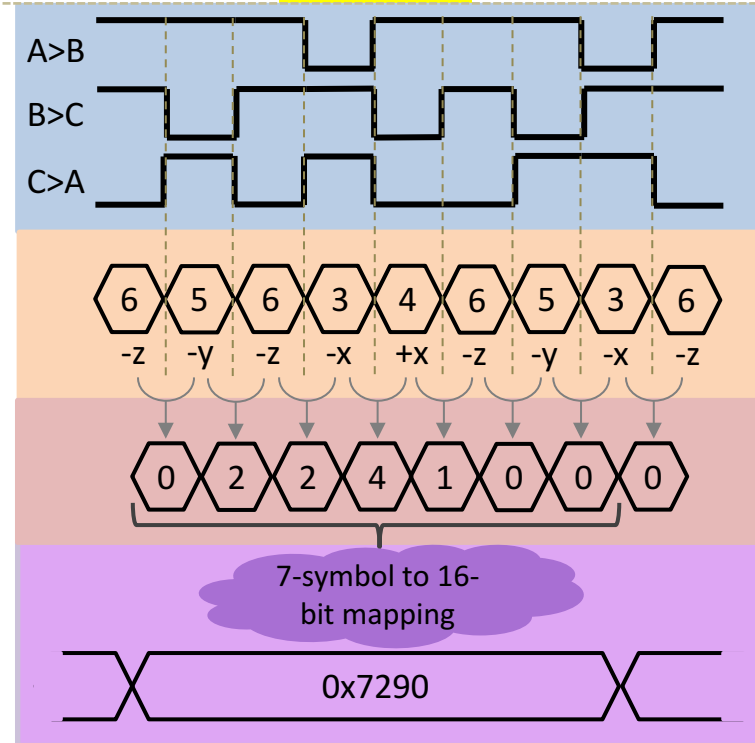
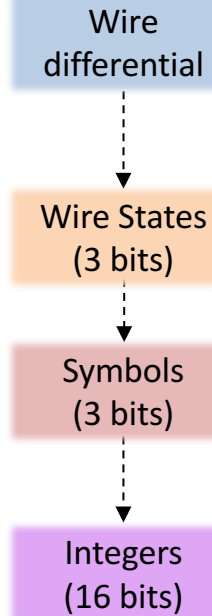
# MIPI CPHY<sup>SM</sup> Data Types

## ANALOG



- 3 wires per lane
- 3-level wires (LOW, MID, HIGH)
- Every unit interval must contain LOW, MID, and HIGH wires
- No two consecutive identical states

## DIGITAL





# Wire States

- A wire state is the collection of A, B, and C
- 6 possible wire states

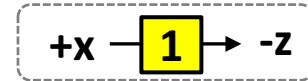
ANALOG			DIGITAL (3 bits)			Wire state name
A	B	C	A>B	B>C	C>A	
HIGH	LOW	MID	1	0	0	+x
LOW	HIGH	MID	0	1	1	-x
MID	HIGH	LOW	0	1	0	+y
MID	LOW	HIGH	1	0	1	-y
LOW	MID	HIGH	0	0	1	+z
HIGH	MID	LOW	1	1	0	-z

# Symbols: Now We're Transmitting!

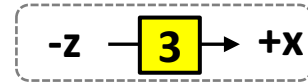
- A symbol represents a transition between two wire states
- 5 possible symbols

	Symbol (3 bits)		
	Flip	Rotate	Polarity
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	DC	DC

Example:



Example:



Flip	
0	-
1	Same letter, toggle sign.

Rotate	
0	Decr. letter
1	Incr. letter

Polarity	
0	-
1	Toggle sign

# Mapping 7 Symbols $\longleftrightarrow$ 16-bit Integers

- MIPI C-PHY<sup>SM</sup> defines a mapping between 7-symbol words and 16-bit integers

Number of **7-symbol words**:

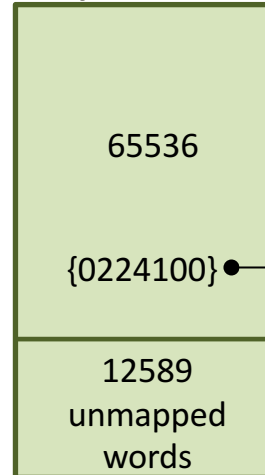
$$5^7 = 78125$$

>

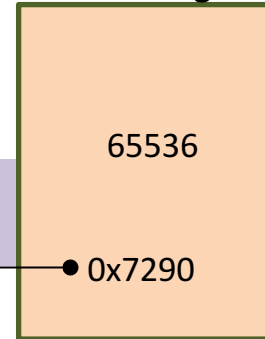
Number of **16-bit integers**:

$$2^{16} = 65536$$

**7-symbol words**

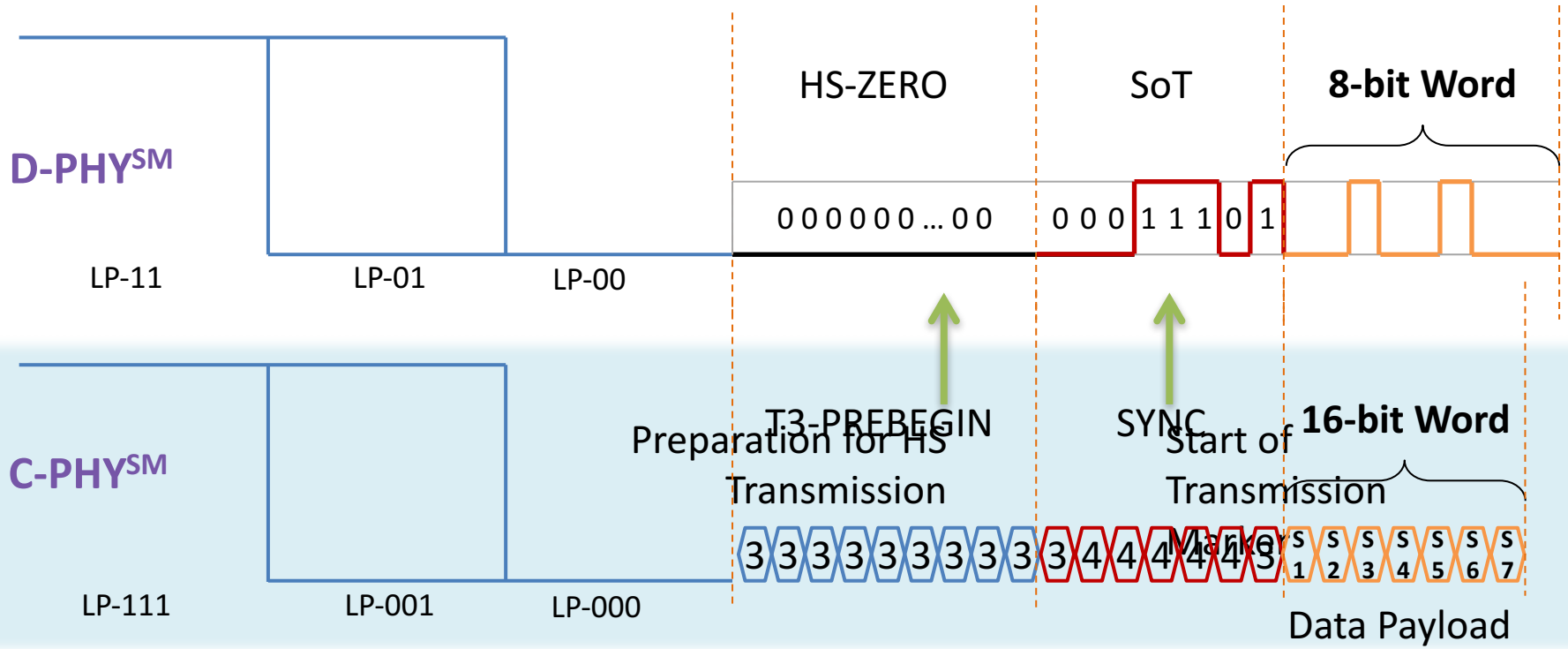


**16-bit integers**



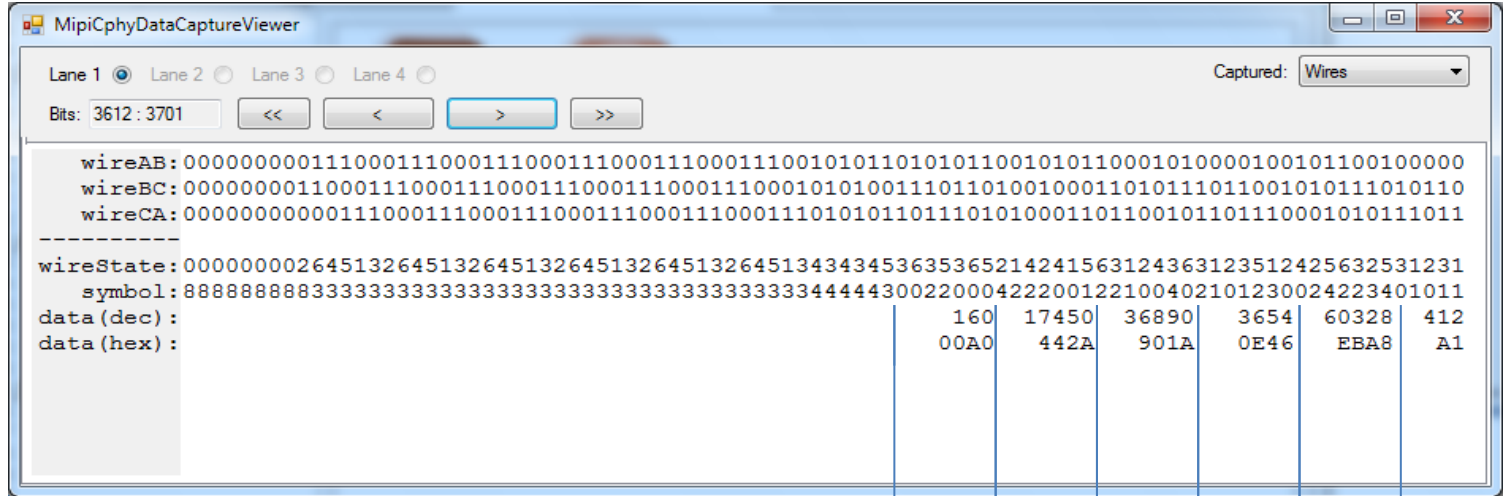
1-to-1  
mapping

# Global Packet Transmission Similar to MIPI D-PHY<sup>SM</sup>



# Tool View

Three-Phase  
Signals



Decoded Data

# MIPI C-PHY's Magical Unmapped Words!

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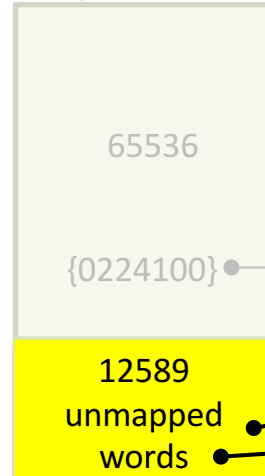
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>

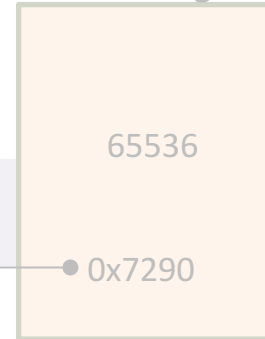
Number of 16-bit integers:

$$2^{16} = 65536$$

7-symbol words



16-bit integers



1-to-1  
mapping

12589  
unmapped  
words

**{3444443}** Sync Word (Alignment marker)

**{4444444}** Post (End-of-Packet marker)





# Send Unmapped Words Within HS Bursts!

MipiCphyDataCaptureViewer

HS\_immediate

lane1  lane2  lane3  lane4

Full Capture Packets

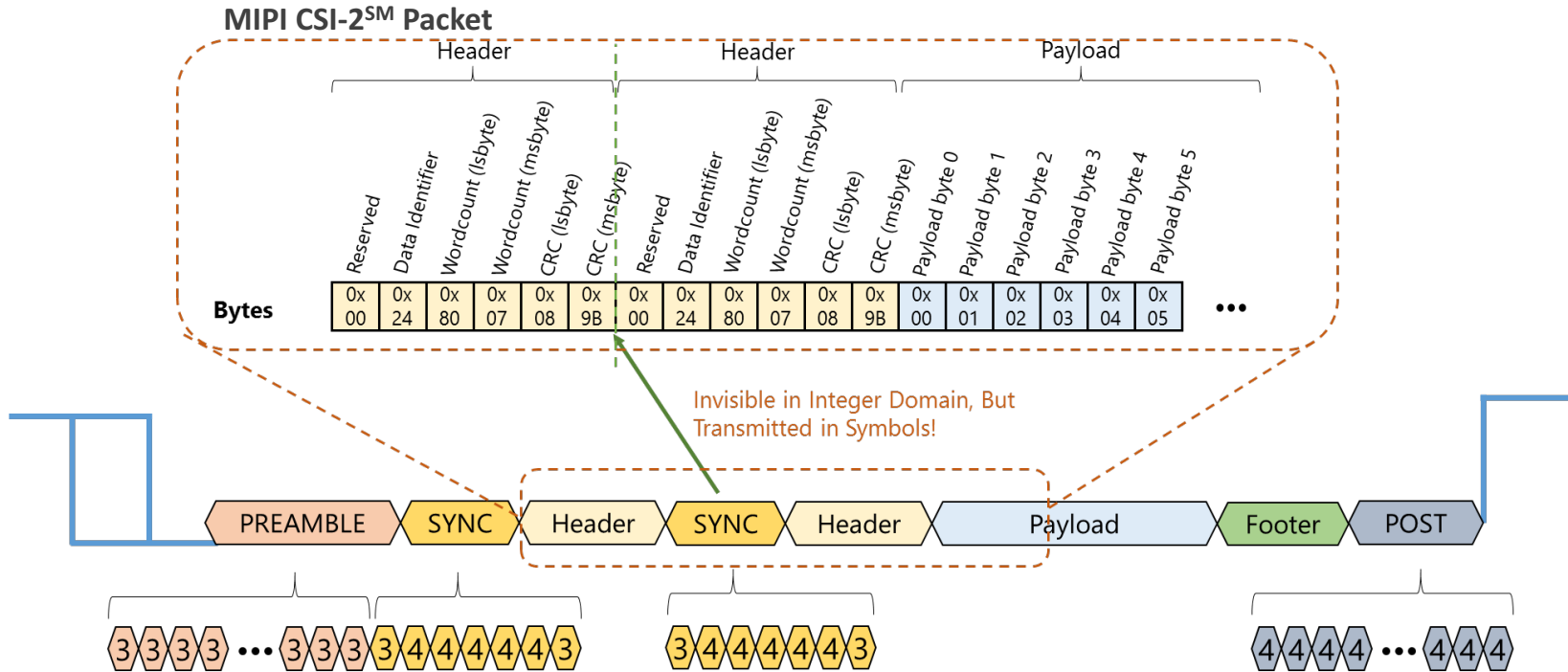
Bits: 254 : 366

```

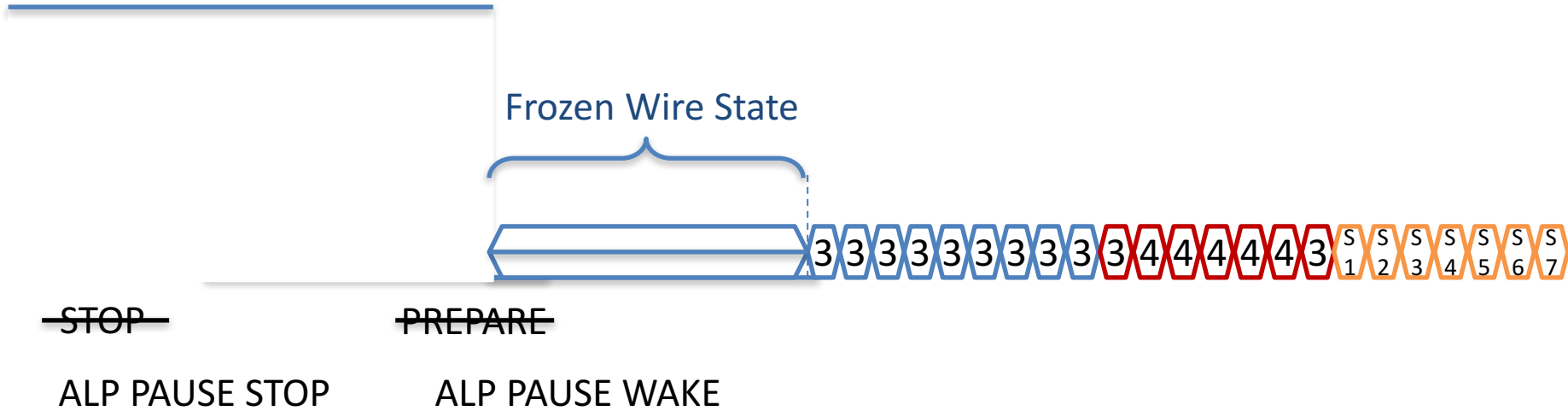
wireAB: 01010111111010010010101110011010101010110110100001101110101000110111010010111100101010111000101100101100010100
wireBC: 01010101010100100101111001000101011101011011010011110101010101110001011001011000101001010101101010001011001001111
wireCA: 101010001010010010110000101010101000001011011010100011001010101101010001011001001111010100011011101001011110010
-----
numBits: 7946688 numSync: 821
wireStates: 16161646565241241253626452145252526242436536534123264356434343235416562412536454613516161646312535412436513152632
symbols: 34444431020400000040013334223444443102040000004001333422344444312104021000400331143234444431210402100040033114323
data (dec) :      32801  32768  35581  None  32801  32768  35581  None  34841  32769  35679  None  34841  32769  35679
data (hex) :      8021   8000   8AFD  None  8021   8000   8AFD  None  8819   8001   8B5F  None  8819   8001   8B5F
    
```



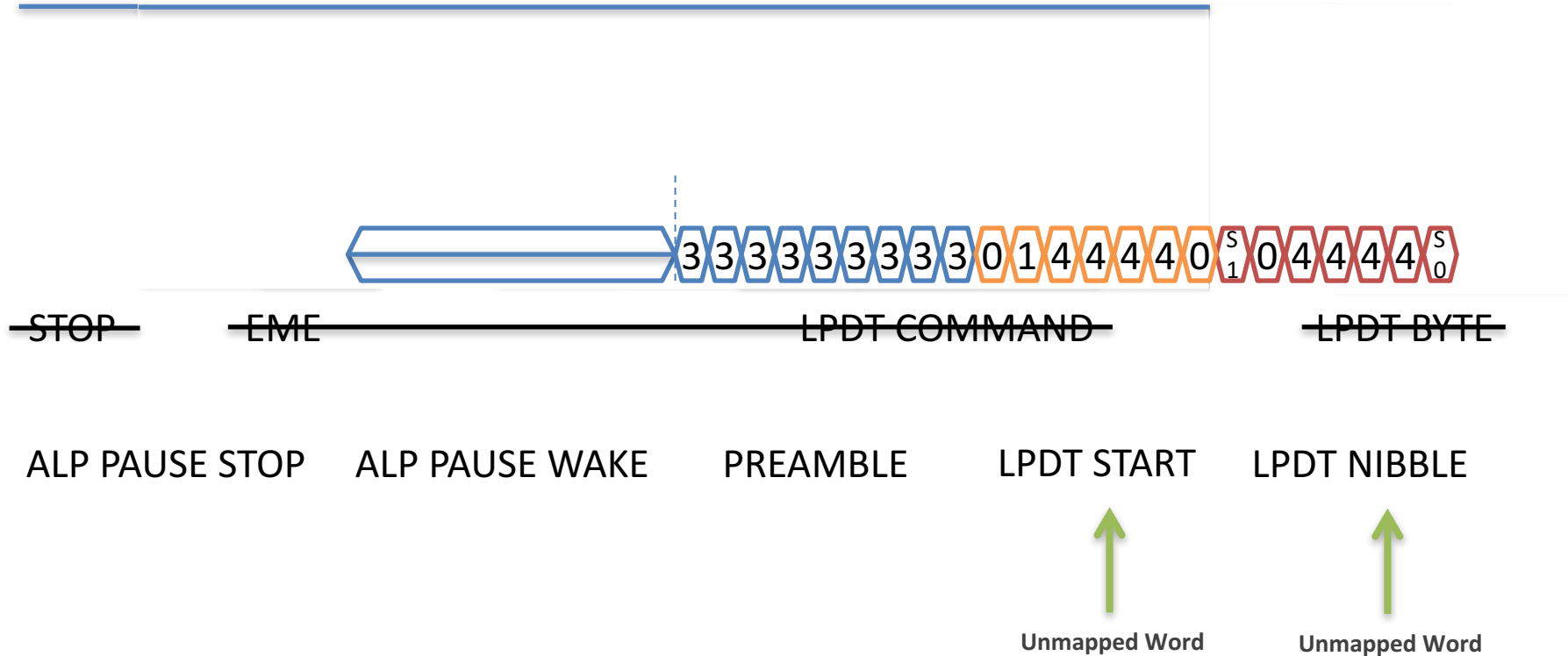
# Example: Packet Header Resynchronization



# Example: Alternate Low Power Mode



# Example: Alternate Low Power Mode



# Unmapped Words Enable a Wide Range of Codes

Symbol Sequence	ALP Function Code
0244440	Stop Code
0244441	ULPS Code
0244442	Trig 1 Code
...	...
4444444	Post2

Same functionality as legacy LP EME Sequences

# Multiple SYNC Word Types

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# SYNC Is an Unmapped Word

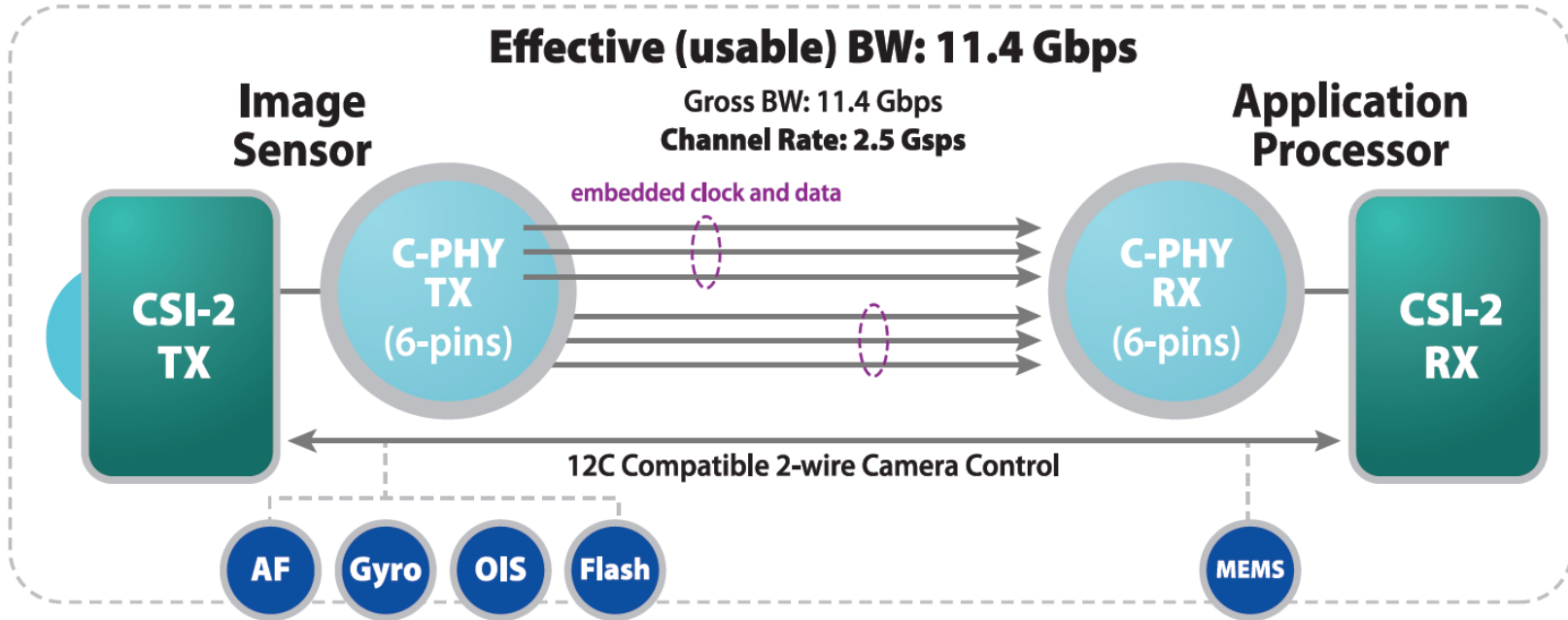
- Five (5) possible SYNC words exist
  - 3444440
  - 3444441
  - ...
- First SYNC word in a burst is always 3444443
- Multiple SYNC words used to trigger different seed types for MIPI CSI-2<sup>SM</sup> scrambling



# MIPI CSI-2<sup>SM</sup> Imaging Features Enabled by C-PHY

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Src: MIPI Alliance

# MIPI CSI-2<sup>SM</sup> Imaging Features Enabled by MIPI C-PHY<sup>SM</sup>

- Long Reach Transport Efficiency (LRTE)
  - Easily delimits packets using **unmapped words**
- ALPS
  - Helps maintain low voltage levels in advanced process nodes
- Up to 32 Virtual Channels
  - Useful for imaging and vision applications supporting **multiple sensor streams**

# MIPI CSI-2<sup>SM</sup> Imaging Features Enabled by MIPI C-PHY<sup>SM</sup>

- Scrambling
  - Provides a **wide range of seed** triggers using multiple SYNC words
- Future support for sensor fusion and camera commands
  - MIPI C-PHY<sup>SM</sup> natively enables future technologies for more efficient camera commands than those using legacy LP mode



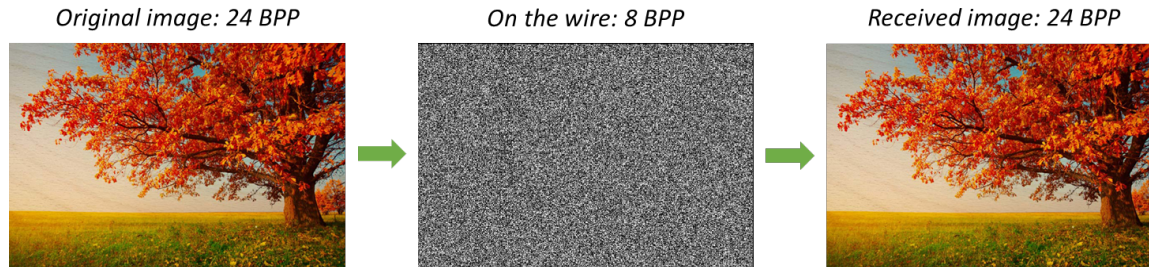
# MIPI DSI-2<sup>SM</sup> Protocol Features Enabled by MIPI C-PHY<sup>SM</sup>

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# MIPI DSI-2<sup>SM</sup> Features Enabled by MIPI C-PHY<sup>SM</sup>

- Display stream compression
  - Complete compatibility with compression needs



# MIPI DSI-2<sup>SM</sup> Features Enabled by MIPI C-PHY<sup>SM</sup>

- MIPI Display Command Set (DCS<sup>SM</sup>) Mode
  - Proven technology for buffered frame transmissions
- Scrambling
  - Full support for scrambling at the protocol level

# Summary

MIPI C-PHY<sup>SM</sup> is based on a three-phase encoding scheme resulting in high transport efficiency over bandwidth-constrained channels

MIPI C-PHY<sup>SM</sup>'s unmapped words create extremely robust control, transmission, and messaging mechanisms at the protocol level

Next generation imaging (MIPI CSI-2<sup>SM</sup>), vision (MIPI CSI-2<sup>SM</sup>), and projection (MIPI DSI-2<sup>SM</sup>) applications can benefit greatly from MIPI C-PHY<sup>SM</sup>'s powerful protocol features





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THANK YOU

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