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Mohamed Hafed Introspect Technology

MIPI C-PHYSM And How It Enables Next Generation Display and Camera Implementations

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US 8,472,551 B2

*Jun. 25, 2013

(10) Patent No.:

(45) Date of Patent:

Original Spark: Three Phase Encoding!

FOREIGN PATENT DOCUMENTS (54) THREE PHASE AND POLARITY ENCODED SERIAL INTERFACE 1871635 A 11/2006 1207649 5/2002 2002199032 A 7/2002 WO2005041164 5/2005 (75) Inventor: George A Wiley, San Diego, CA (US) (73) Assignce: QUALCOMM Incorporated, San OTHER PUBLICATIONS International Source Report and Writen Opinion—PCTU82008 International Source Report and Writen Opinion—PCTU82008 Secarato J., "Multimedia messaging service for OPINS and UMTers-New 24, 2008. Secarato J., "Multimedia messaging service for OPINS and UMTers-Net To PCTURE Sec. 2009, pp. 112–11458, vol. 3 IEEE on PCTURE Sec. 2009, pp. 112–11458, vol. 3 Security J., Status P., Polyane D., Status Wei, High-Speel I.O. Links, "Produced Disasteriations and Theses, 2019, UCL-A. Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days. This patent is subject to a terminal dis-Japane P.O. Links, "Frequencies Dissociations and Fineses, 2016, CCLA, 189 pages, John Poulton, et al., "Multiwire Differential Signaling," UNC-CH Department of Computer Science, Version 1.1, Aug. 6, 2003. (21) Appl. No.: 13/301,454 (22) Filed: Nov. 21, 2011 (Continued) **Prior Publication Data** Primary Examiner — Shuwang Liu Assistant Examiner — James M Perez (74) Attorney: Agent, or Firm — Kevin T. Cheatham; US 2012/0155565 A1 Jun. 21, 2012 Related U.S. Application Data Raphael Freiwirth (63) Continuation of application No. 11/712,941, filed on Mar. 2, 2007, now Pat. No. 8,064,535. 1 Unit Interval of 2.285 Bits of (57) ABSTRACT A high speed serial interface is provided. In one aspect, the (51) Int. Cl. high speed serial interface uses three phase modulation for jointly encoding data and clock information. Accordingly, the H04L 25/34 H04L 25/49 (2006.01) (2006.01) need for de-skewing circuitry at the receiving end of the (52) U.S. CL USPC interface is eliminated, resulting in reduced link start-up time and improved link efficiency and power consumption. In one embodiment, the high speed serial interface uses fewer signal 375/288; 375/289; 375/292; 341/58; Information 341/69; 341/70 (58) Field of Classification Search conductors than conventional systems having separate con-ductors for data and clock information. In another embodi-ment, the serial interface allows for data to be transmitted at USPC 375/259-264, 284-288, 290-293; 341/50, 341/58, 68-70 See application file for complete search history. any speed without the receiving end having prior knowledge of the transmission data rate. In another aspect, the high speed serial interface uses polarity encoded three phase modulation (56) References Cited for jointly encoding data and clock information. This further U.S. PATENT DOCUMENTS for more than one bit to be transmitted in any single baud 5/1980 Ahamed 11/1993 Carlstedt 10/1994 Weddle et al. 4,201,958 A 5,259,002 interval (Continued) 39 Claims, 15 Drawing Sheets ~ 311

George Wiley, Qualcomm

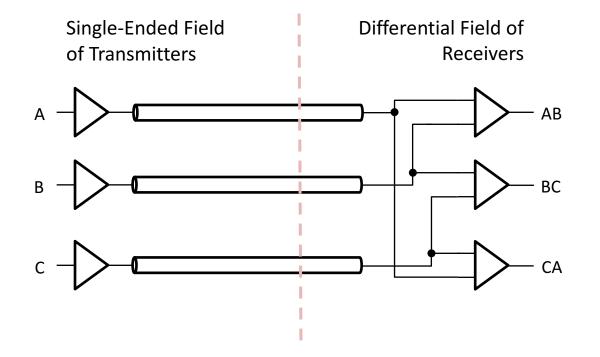
(12) United States Patent

Wiles

Data

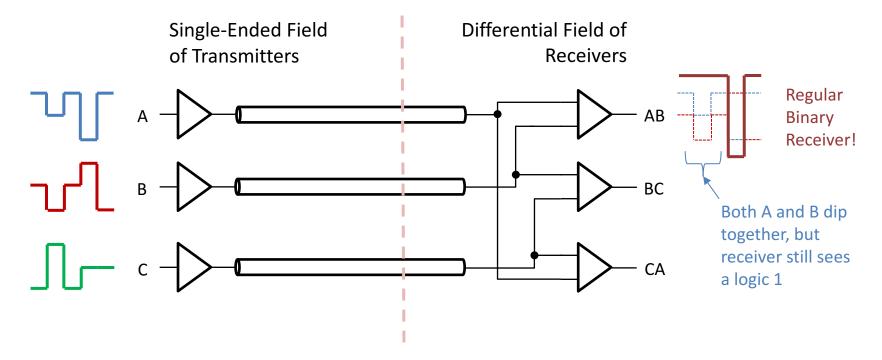


Basic Concept – One Trio

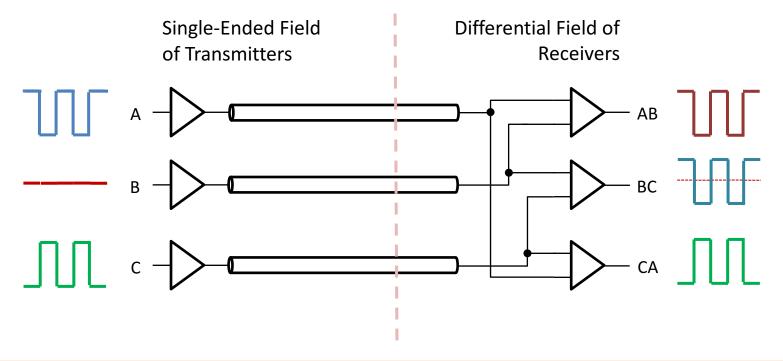




Three Voltage Levels Ensure Proper Differential Reception





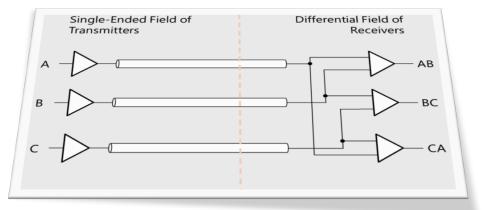




Key Takeaways

Three-level single-ended signaling

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

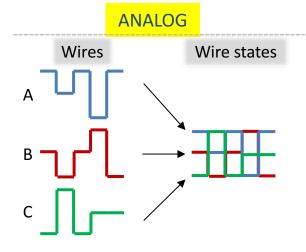


Encoding and Mapping

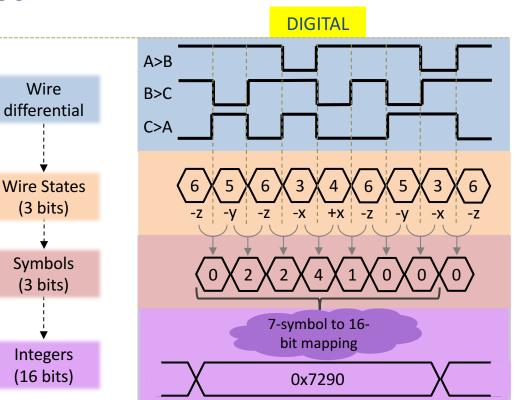




MIPI CPHYSM Data Types



- 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





Wire States

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

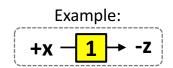
	ANALOG		DIGITAL (3 bits)			
Α	В	С	A>B	B>C	C>A	Wire state name
HIGH	LOW	MID	1	0	0	+x
LOW	HIGH	MID	0	1	1	-x
MID	HIGH	LOW	0	1	0	+у
MID	LOW	HIGH	1	0	1	-у
LOW	MID	HIGH	0	0	1	+z
HIGH	MID	LOW	1	1	0	-Z

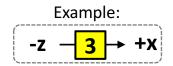


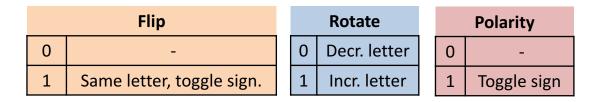
Symbols: Now We're Transmitting!

- 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	



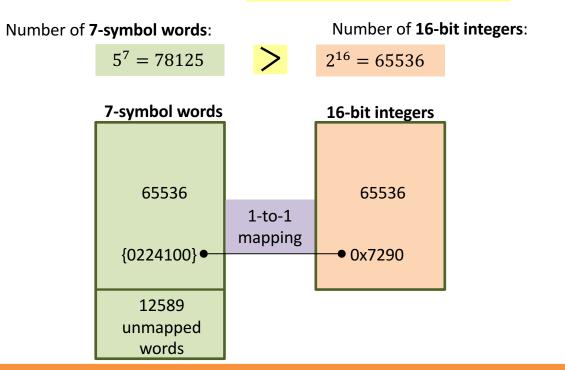






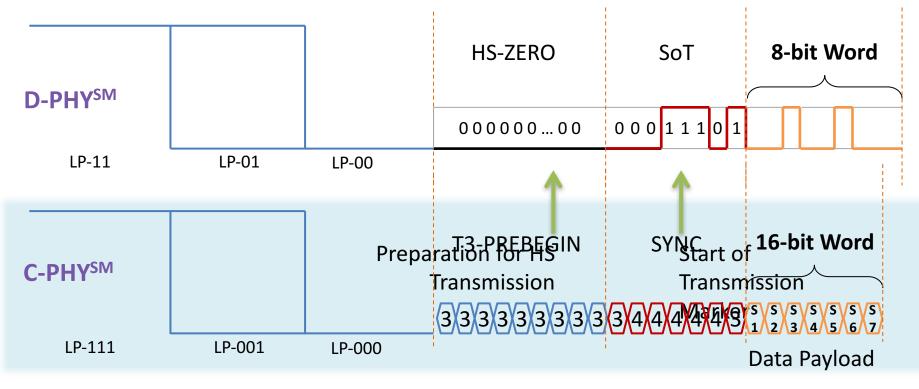
Mapping 7 Symbols \iff 16-bit Integers

• MIPI C-PHYSM defines a mapping between 7-symbol words and 16-bit integers





Global Packet Transmission Similar to MIPI D-PHYSM





Tool View

	HipiCphyDataCaptureViewer	
Three-Phase Signals	Lane 1 @ Lane 2 Lane 3 Lane 4 Bits: 3612:3701 wireAB: 0000000011100011100011100011100011100101	011001010111010110 1011100010101111011 123512425632531231
	data(hex): 00A0 442A 901A	0E46 EBA8 A1

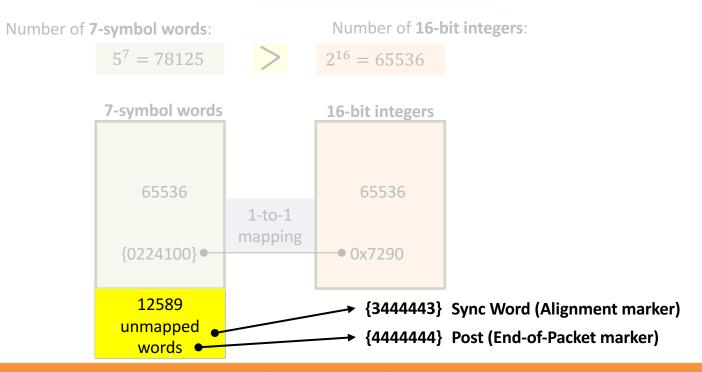
Decoded Data

MIPI C-PHY's Magical Unmapped Words!



MIPI C-PHY's Magical Unmapped Words!

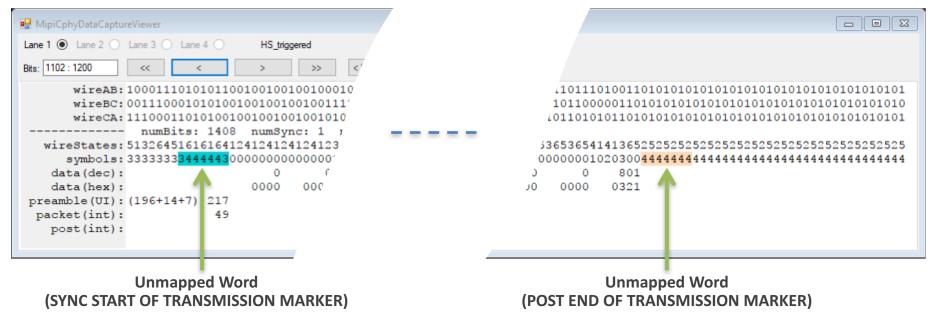
• MIPI C-PHYSM defines a mapping between 7-symbol words and 16-bit integers





Easily Delineate Bursts... Really Easily!

SYNC and POST



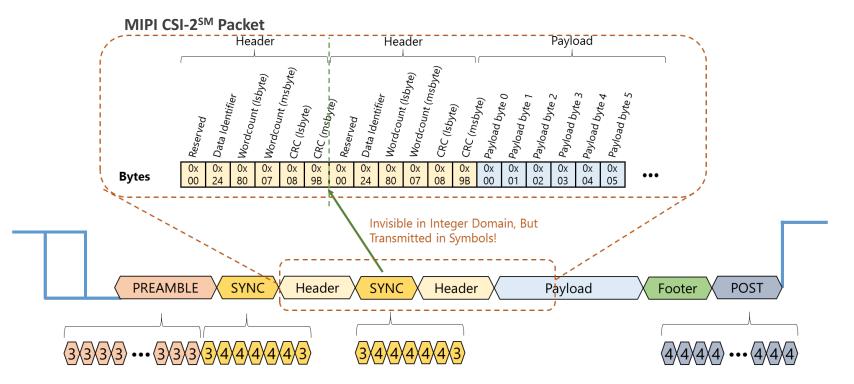


Send Unmapped Words Within HS Bursts!

🖳 MipiCphyDataCaptureViewer				
HS_immediate				
● lane1 ○ lane2 ○ lane3 ○ lane4				
Full Capture Packets				
Bits: 254 : 366 << >	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	Find		
wireAB: 0101011111101001003	101011100110101010101010101	1010000110111010100011011101	00101111100101010111000101	100101100010100
wireBC: 0101010101010010010	01111001000101011101011011	0100111101010101011100010110	01011000101001010101101010	001011001001111
wireCA: 101010001010010010	110000101010101000000010110)1101010001100101010110101000	10110010011110101000110111	010010111110010
numBits: 7946688	numSync: 821			
wireStates: 1616164656524124123	53626452145252526242436530	55341232643564343432354165624	12536454613516161646312535	412436513152632
symbols: 344444310204000004	40013334223444443102040000	00040013334223444443121040210	00400331143234444431210402	100040033114323
data(dec): 32801 327	768 35581 <mark>None</mark> 32801	32768 35581 <mark>None</mark> 34841	32769 35679 None 34841	32769 35679
data(hex): 8021 80	000 8AFD 8021	8000 8AFD 8819	8001 8B5F 8819	8001 8B5F
		•		
	A		A	
	T	T		

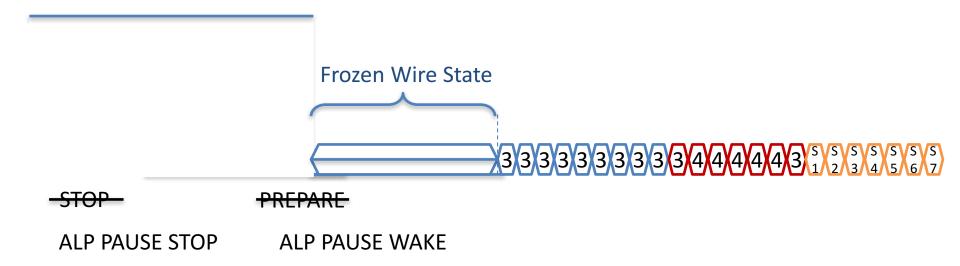


Example: Packet Header Resynchronization



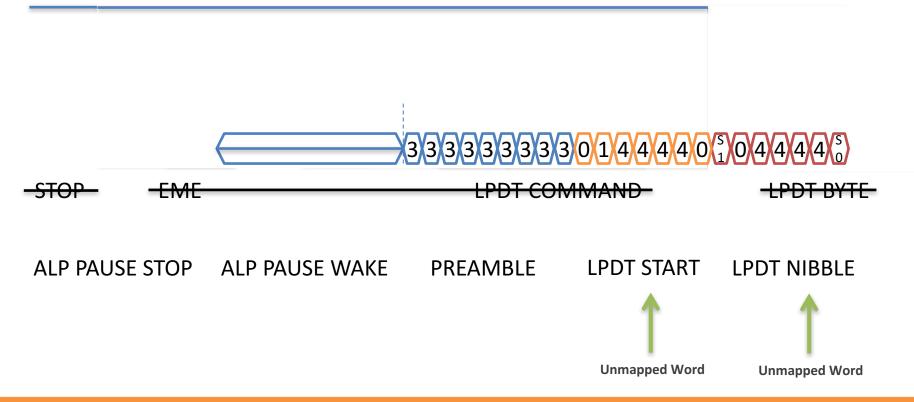


Example: Alternate Low Power Mode





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
444444	Post2

Same functionality as legacy LP EME Sequences

Multiple SYNC Word Types

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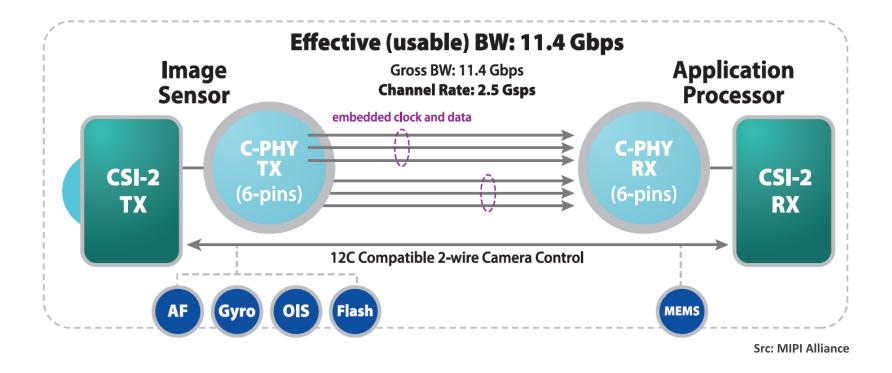


SYNC Is an Unmapped Word

- Five (5) possible SYNC words exist
 - 344440
 - 3444441
 - •••
- First SYNC word in a burst is always 3444443
- Multiple SYNC words used to trigger different seed types for MIPI CSI-2SM scrambling

MIPI CSI-2SM Imaging Features Enabled by C-PHY







MIPI CSI-2SM Imaging Features Enabled by MIPI C-PHYSM

- 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-2SM Imaging Features Enabled by MIPI C-PHYSM

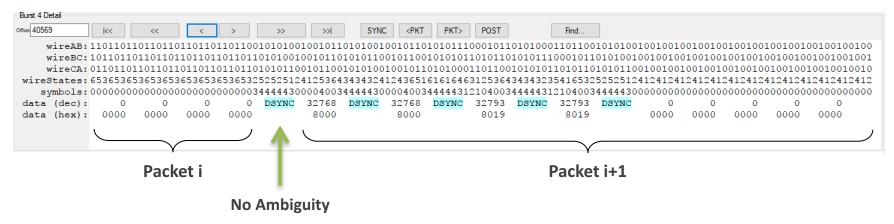
- Scrambling
 - Provides a **wide range of seed** triggers using multiple SYNC words
- Future support for sensor fusion and camera commands
 - MIPI C-PHYSM natively enables future technologies for more efficient camera commands than those using legacy LP mode

MIPI DSI-2SM Protocol Features Enabled by MIPI C-PHYSM



MIPI DSI-2SM Features Enabled by MIPI C-PHYSM

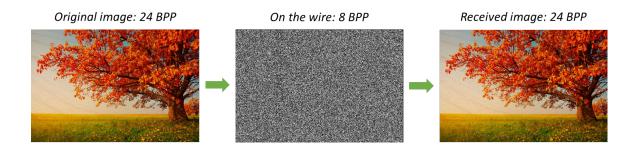
- Fast packets
 - Unmapped words enable very robust packet delimiting within a burst





MIPI DSI-2SM Features Enabled by MIPI C-PHYSM

- Display stream compression
 - Complete compatibility with compression needs





MIPI DSI-2SM Features Enabled by MIPI C-PHYSM

- MIPI Display Command Set (DCSSM) Mode
 - Proven technology for buffered frame transmissions
- Scrambling
 - Full support for scrambling at the protocol level



Summary

MIPI C-PHYSM is based on a three-phase encoding scheme resulting in high transport efficiency over bandwidth-constrained channels

MIPI C-PHYSM's unmapped words create extremely robust control, transmission, and messaging mechanisms at the protocol level

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

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