Agenda

- Touch Architectures and Topology

- Stack-up of Related MIPI Touch Specifications

- Touch Command Layer Model

- Overview of MIPI Touch Command Set (MIPI TCS^{SM})

- Touch Report Data Structure

  - Micro-Frames

- Detailed review of important touch commands

Current Industry Touch Status

- Current status – non-standard touch command sets
- Non-standard link-layer protocols
  - SPI/I2C
- Not optimized
  - Low-power mobile performance
  - Low-cost pin-count interfaces
- More touch bandwidth required
- Improved touch latency required

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New MIPI Touch Standard

- MIPI TCS is link-layer and physical-layer agnostic

- Simplified standard commands

- MIPI Touch Adaptation Layer for I3C (MIPI ALI3C^{SM})
  - Works seamlessly with MIPI Specification for I3C (MIPI I3C^{SM})
  - Fully Utilizes MIPI I3C In-Band-Interrupts
    - Low-latency ([Link to motivational example](#))
    - High-Bandwidth
 - Wide touch system topology supported

Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.

Building on MIPI Specifications
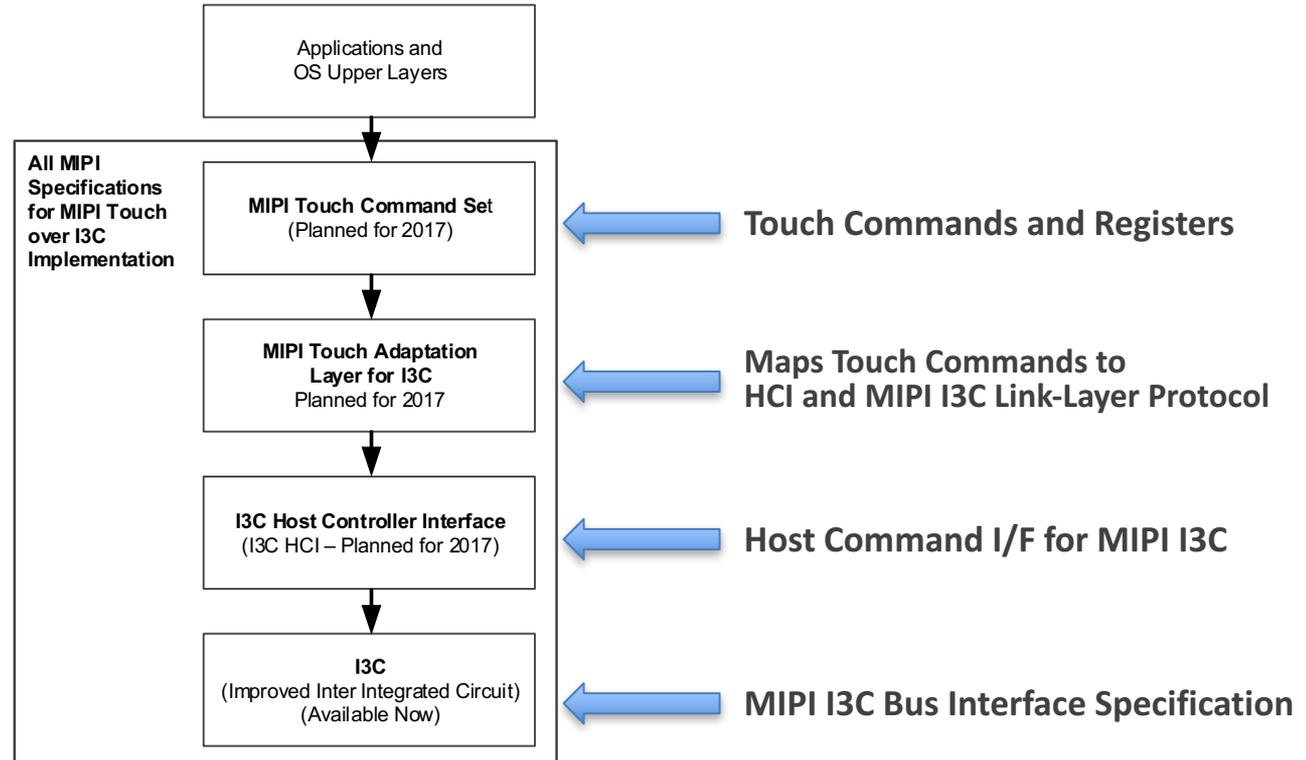
Applications and
OS Upper Layers

All MIPI
Specifications
for MIPI Touch
over I3C
Implementation

MIPI Touch Command Set
(Planned for 2017)

**MIPI Touch Adaptation
Layer for I3C**
Planned for 2017

I3C Host Controller Interface
(I3C HCI – Planned for 2017)

I3C
(Improved Inter Integrated Circuit)
(Available Now)

Touch Commands and Registers

**Maps Touch Commands to
HCI and MIPI I3C Link-Layer Protocol**

Host Command I/F for MIPI I3C

MIPI I3C Bus Interface Specification

**Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.**

Mixed Topology
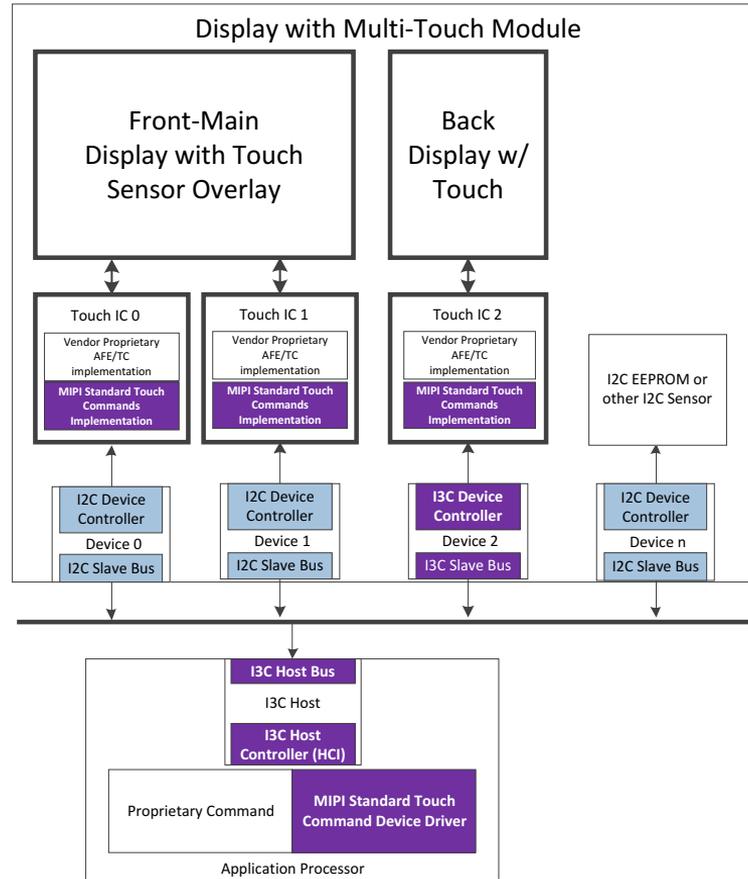
Type 1 – Storage on Host Touch Architecture
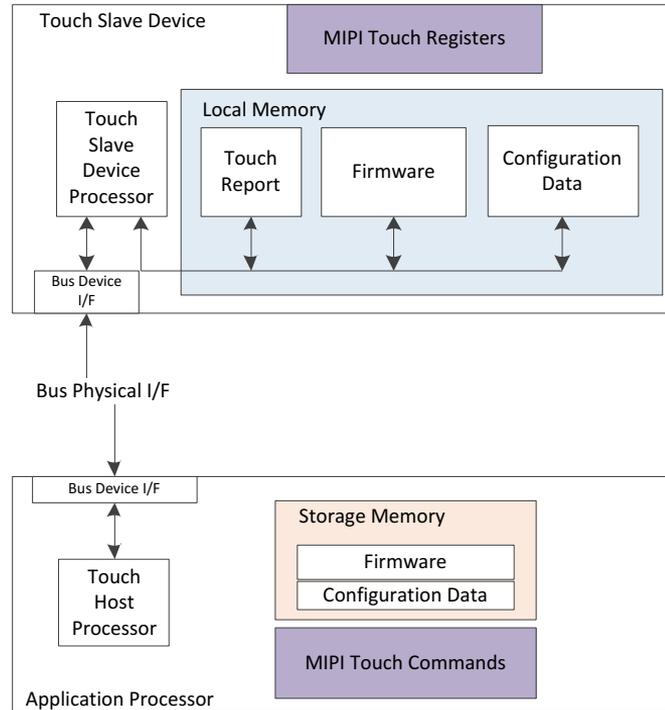
Type 2- Storage on Slave Touch Processor Architecture
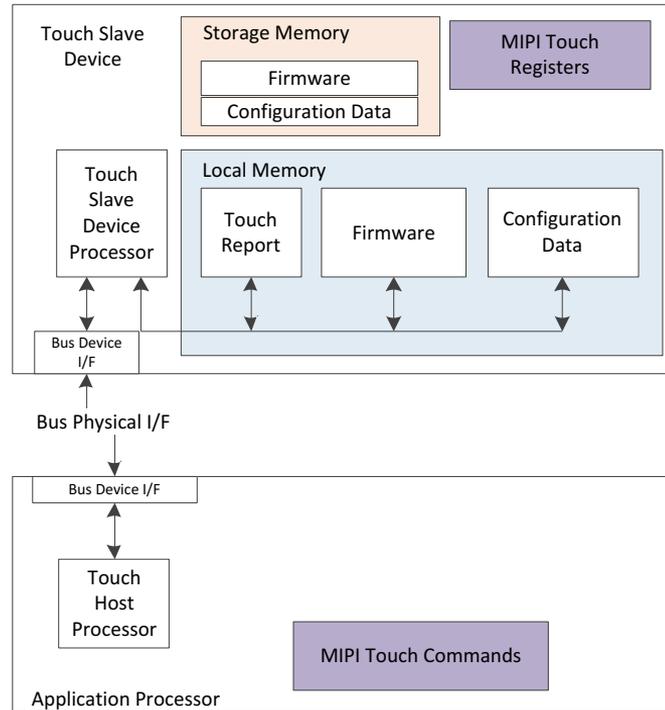
MIPI Touch Command Layer Model

Host Application Processor

| Host Operating System |
| Touch Host Device Driver |
| Host Link-Layer Driver (e.g. I3C HCI or I/O Driver) |
| **Physical Bus Layer Hardware** |

Touch Slave Device

| Touch Slave Device OS (TCS Implementation) |
| Touch Slave Device Driver (TCS Implementation) |
| Slave Link-Layer Driver (e.g. I3C or I/O Driver) |
| **Physical Bus Layer Hardware** |

PHY Independent Layers

PHY Dependent Layers

Physical Bus Interconnect
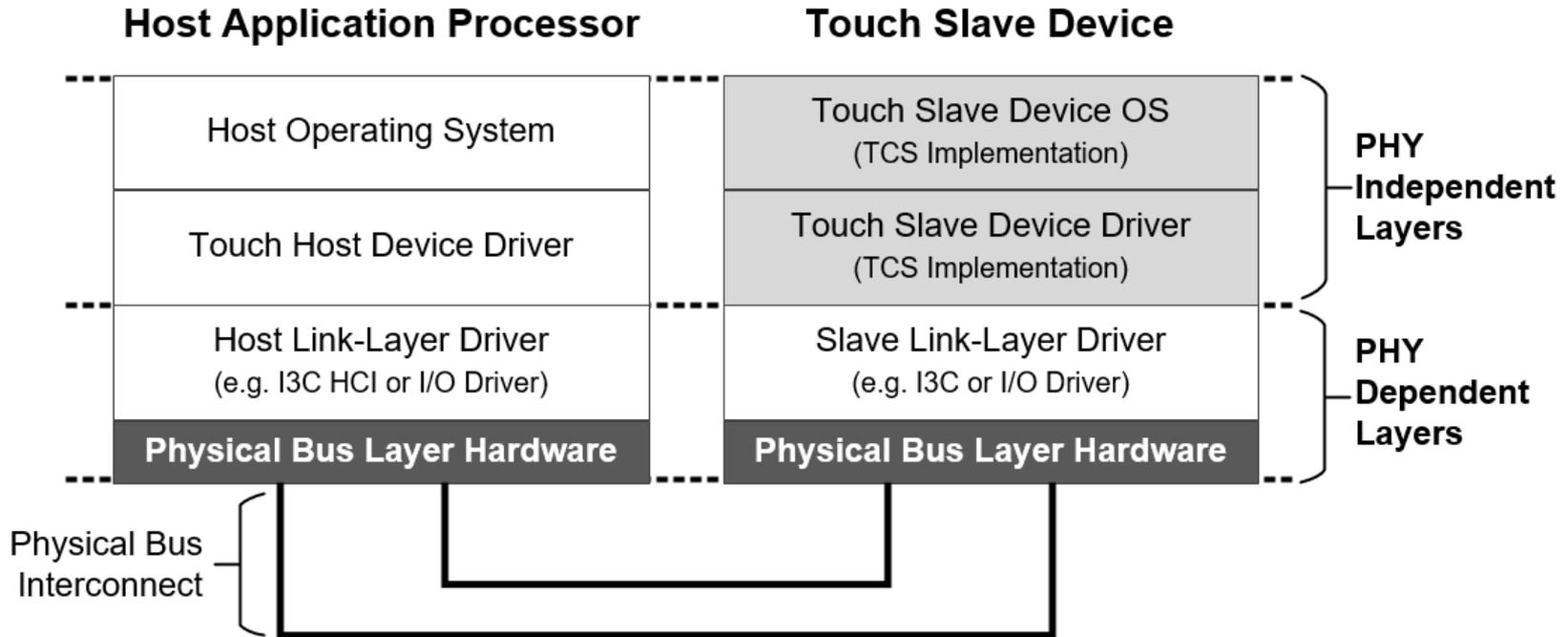
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MIPI Touch Host Commands

| Command Name	Hex Code	Command Payload	Brief Description	Requires Command Done
mtcs_get_touch_report	8'h40	Byte Command Code	Request touch slave device to return a single touch report.	No
mtcs_write_firmware	8'h41	Maximum write length of host	Transfers firmware from the host to the device.	Yes
mtcs_write_configuration_data	8'h42	Maximum write length of host	Transfers touch configuration data from host to device.	Yes
mtcs_self_test	8'h43	Byte Command Code	Activates device self-test.	Yes
mtcs_soft_reset	8'h44	Byte Command Code	Activates device soft reset.	No

Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.

MIPI Touch Host Commands

Register Name	Offset	Description	Access
mtcs_get_interrupt_type	00h	Returns interrupt type	RO
mtcs_set_get_configuration	04h	Set or Get Touch slave device Configuration	Read modify write
mtcs_get_capabilities_information	08h	Get the capabilities of the touch slave device	RO
mtcs_get_current_touch_report_type	0Ch	Get the type of the latest returned touch report	RO
mtcs_get_micro_frame_size	0Dh	Get manufacturer device information	RO
mtcs_get_manufacturer_information	12h	Get manufacturer device information	RO
mtcs_get_device_version_information	16h	Get manufacturer device hardware and firmware revision information	RO
mtcs_get_command_set_version_information	1Ah	Get MIPI command set revision	RO

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MIPI Micro-frame Touch Report Structure

Total M bytes

EH	Touch Frame Report

EH	uFrame 0	uFrame 1	uFrame 2		uFrame N-2	uFrame N-1

m bytes   m bytes   m bytes   m bytes   m' bytes

Total m x (N-1) + m' byte = M byte
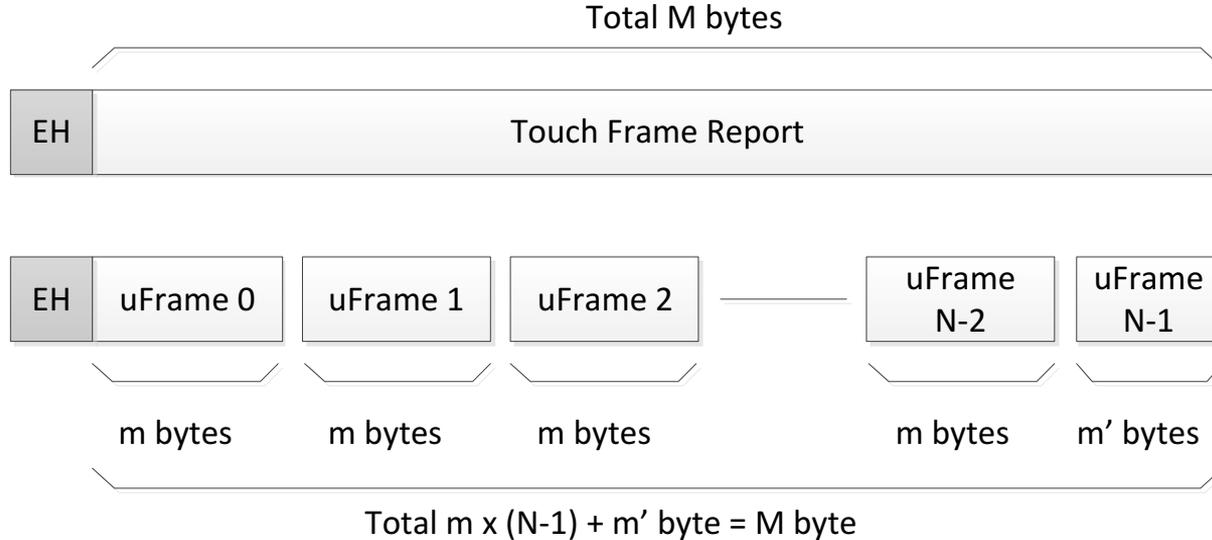
(noted: m' shall be equal to or smaller than m)

EH	Enhanced Header: 2 bytes

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MIPI Basic Touch Report Structure Enhanced Header

Bit Byte	7		6	5	4	3	2	1	0
0	Reserved		Touch data report type: 0 = RAW_MANUFACTURER_REPORT 1 = LINUX_ANDROID_REPORT 2 = HID_REPORT 3 = HID_DESCRIPTOR 4 = HID_REPORT_DESCRIPTOR 5 = HID_PHYSICAL_DESCRIPTOR 6..127 = RESERVED						
1	• transaction_id: Monotonic counter incrementing with each report. Rolls-over to 0 after 2^8-1. [7:0]								
2..N	• Rest of touch report up to N bytes								

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POR Initialization

Touch Slave Device
Power-On Reset

Touch Slave Device
Initialize Registers
mtcs_get_manufacturer_information
mtcs_get_device_version_information
mtcs_get_command_set_version_information

Load and Initialize Firmware

Load and Initialize Configuration Data

Touch Slave Device
Update FW Version Registers
mtcs_get_device_version_information

Touch Slave Device
Set **mtcs_get_interrupt_type[operational_status]**
to **READY_FOR_OPERATION**

Touch Slave Device
Ready for Touch Sensing
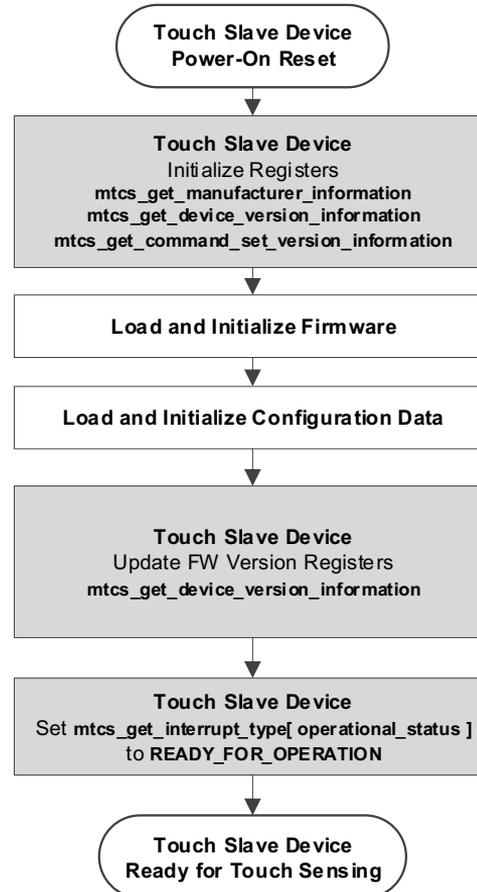
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MIPI Touch Adaptation Layer for I3C (MIPI ALI3C)

MIPI I3C Capability	Device Profile			
	Legacy I^{2}C Profile	I3C SDR Profile	I3C DDR Profile	I3C Ternary Profile
Co-exists with other Legacy I^{2}C Devices	Required	Required	Optional	Not allowed
I3C Single Data Rate[a]	Required	Required	Required	Required
I3C Double Data Rate	N/A	Not allowed	Required	Optional
HDR-Ternary Symbol Legacy	N/A	Not allowed	Not allowed	Not allowed
HDR-Ternary Symbol for a Pure Bus	N/A	Not allowed	Not allowed	Required
Dynamic Address (I3C Section 5.1.4)	N/A	No Provisional ID Required	No Provisional ID Required	No Provisional ID Required
Hot-Join (I3C Section 5.1.5)	N/A	Limited[d]	Limited[d]	Limited[d]
In-Band Interrupt [b] (I3C Section 5.1.6)	N/A	Required	Required	Required
Secondary Master (I3C Section 5.1.7)	Not allowed	Not allowed	Not allowed	Not allowed
Approximate Bandwidth	1 Mb/s	12 Mb/s	25 Mb/s	39 Mb/s
Required CCC	No[c]	GETMWL GETMRL	GETMWL GETMRL	GETMWL GETMRL
DCR Human machine interface function (see 4.6)	No	Required	Required	Required

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Legacy I2C Interrupts
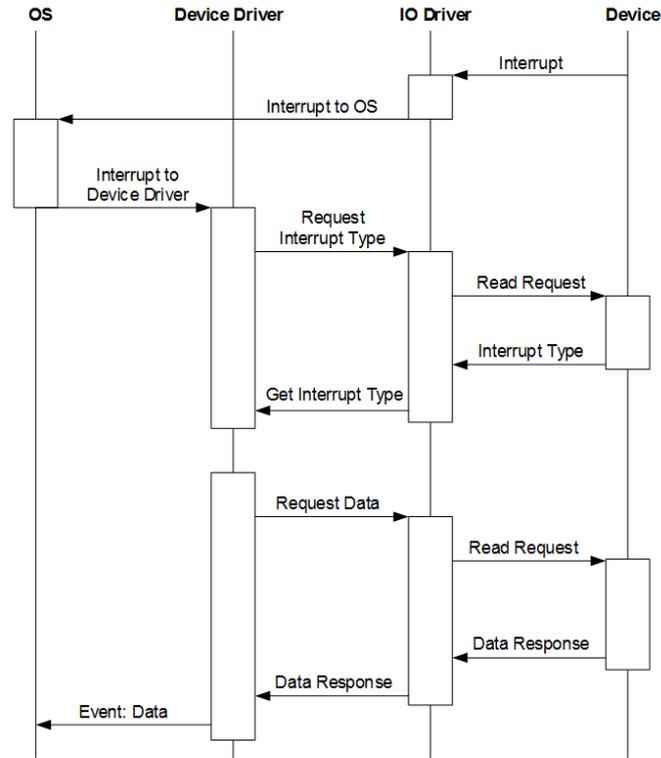
Figure 7 Out-of-Band Interrupt Signal Flow

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MIPI I3C Standard

1214   1.   Accept the IBI by providing the ACK bit. The actions available to the Current Master depend upon
1215   the value of the Slave's BCR [2] bit (in the Slave's BCR register):

1216   a.   If the I3C Slave's BCR [2] bit is set to 1, then, per *Section 5.1.1.2.1*, the Current Master shall
1217   read the Mandatory Data Byte that follows the accepted IBI request at any "read" clock speed
1218   allowable by the Slave. This operation is similar to a "read" from the Slave and all the related
1219   rules apply. Note that the Current Master cannot avoid receiving the Mandatory Data Byte,
1220   since it is transmitted in Push-Pull mode.

1221   After reading the Mandatory Data Byte, the Current Master may take any other valid I3C
1222   action. For example, the Current Master could issue a STOP, or issue a Repeated START,
1223   or it could continuing reading additional Data Bytes from the Slave (if, for example, a
1224   private contract between the two Devices has been established in advance).

1225   One conceptual time diagram of this sequence is shown in *Figure 20* below:

Open Drain	Open Drain	Open Drain	Hand Off	Push-Pull	Drive High or Low, and then High-Z	Push-Pull
S	Slave_addr_as_IBI/R	Master_ACK	SCL High	Slave_byte	T	Sr

1226   **Figure 20 IBI Sequence with Mandatory Data Byte**

* MIPI Specification for MIPI I3C – Section 5.1.6.2 MIPI I3C Slave Interrupt Request

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MIPI Touch Adaptation Layer for MIPI I3C (ALI3C)

4.4.1.2   In-Band Interrupt Mandatory Data Byte

153 The Mandatory Data Byte (MDB) shown in Figure 1 shall be part of an IBI. Per the I3C Specification
154 [MIPI01], bit [2] of the I3C Bus Characteristics Register shall be set to 1'b1 when IBI are used.

155 In addition to the MDB, Slave Devices may also include further optional data providing that the following
156 requirements are met:

157 • If bit 7 of the MDB is set (1'b1), then the MDB can be used for I3C Timing Control.

158   For details on I3C Timing Control, see Section 5.1.8 of the I3C Specification [MIPI01].

159 • If bit 6 of the MDB is set (1'b1), then the additional data shall be read using the I3C HCI Auto-
160   Command protocol; if bit 6 is clear (1'b0), then the additional data shall be sent following the
161   MDB.

162   In both cases, the Slave Device shall terminate after the data has been sent. For details on the I3C
163   HCI Auto-Command protocol, see in 6.11 of the I3C HCI Specification [MIPI02].

164 The source of the interrupt shall clear upon transfer of the MDB.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0: Normal 1: Timing Control	0: Normal 1: Auto-Command	Interrupt Type, defined by Command Specification (Unused bits default to 0)					

Figure 1. IBI Mandatory Data Byte

MIPI Touch Adaptation Layer for MIPI I3C – 4.4.1.2 In-Band Interrupt Mandatory Data Byte

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MIPI I3C Host Controller Interface – Draft Specification
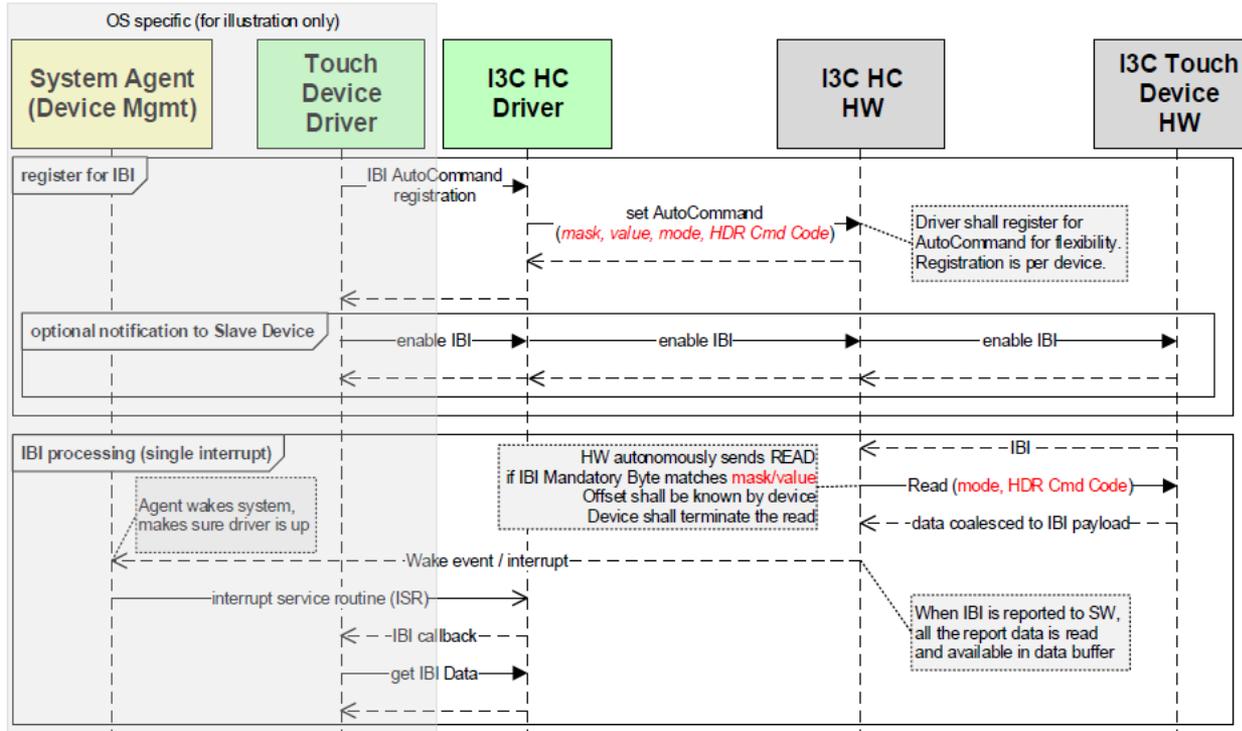
MIPI I3C Host Controller Interface – Section 6.11 Auto-Command

Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.

MIPI I3C IBI - Mandatory Data Byte (MDB)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0: Normal **1: Timing Control**	0: Normal 1: Auto-Command	Interrupt Type, defined by Command Specification (Unused bits default to 0)					

Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.

# Summary and Key Take Away Points

- MIPI Touch = 4x MIPI Specifications
  - MIPI Touch Command Set
  - MIPI Adaptation Layer MIPI I3C,
  - MIPI HCI for MIPI I3C
  - MIPI I3C
- Improved Touch Performance
  - Simplifies Software and Hardware design
  - Improved latency
  - Highest Throughput
  - Compatibility with MIPI Specifications eco-system

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Background Section

Traditional I2C Transaction
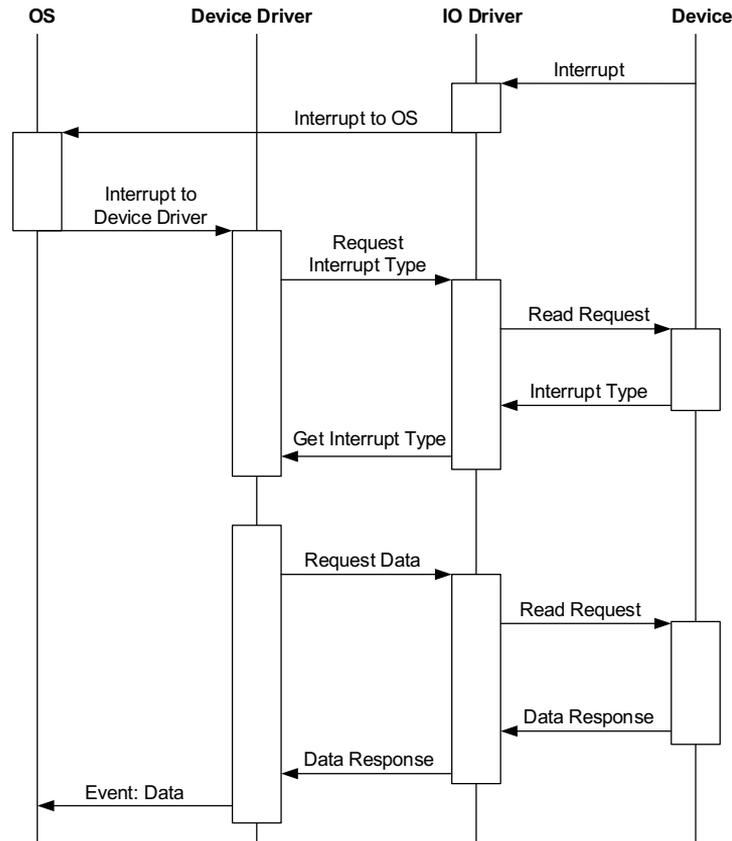
Return

MIPI Touch MIPI I3C SDR and HDR Transactions

#	Mode	SDR Auto-Append								
		Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull	Push-Pull	
1	Activate TOUCH_EN	START	I3C Reserved Byte/W (7'h7E/W)	Slave_ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave_ACK	Write mtcs_set_get_configuration Addr/W · T	Write touch_en = TOUCH_ENABLED · T	STOP

#	Mode	SDR Auto-Append											
		Open Drain	Open Drain	Open Drain	Hand Off	Push-Pull		SDR Touch Report 1					
2	SDR with Appended Report IBI MDB Indicates:	START	Touch_SLAVE_addr_as_IBI/R	Master_ACK	T	MDB	T	Touch Data · T	Touch Data · T	....	Touch Data	T	STOP

.... Continues Touch Slave Device touch report generation ....

#	Mode	SDR Auto-Append											
		Open Drain	Open Drain	Open Drain	Hand Off	Push-Pull		SDR Touch Report n					
3	MDB Indicates: REPORT_DATA_AVAILABLE_END_OF_FRAME	START	Touch_SLAVE_addr_as_IBI/R	Master_ACK	T	MDB	T	Touch Data · T	Touch Data · T	....	Touch Data	T	STOP

#	Mode	SDR Auto-Append								
		Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull	Push-Pull	
4	De-activate TOUCH_EN	START	I3C Reserved Byte/W (7'h7E/W)	Slave_ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave_ACK	Write mtcs_set_get_configuration Addr/W · T	Write touch_en = TOUCH_DISABLED · T	STOP

Legend:
- From Master to Slave (purple)
- Transition Bit (Parity bit for WRITE) (blue)
- From Slave to Master (gray)
- Transition Bit (End-of-Data for READ DATA) (orange)

Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.

| # | Mode | HDR Auto-Command | | | | | | | | | | | | |

Row 0 — Configure private read for mtcs_read_touch_report (8'h40)

Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull			
START	I3C Reserved Byte/W (7'h7E/W)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave_ACK	Write mtcs_read_report 8'h40/W	T-bit=LOW	STOP	

Row 1 — Activate TOUCH_EN

Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull		Push-Pull		
START	I3C Reserved Byte/W (7'h7E/W)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave_ACK	Write mtcs_set_get_configuration Addr/W	T	Write touch_en = TOUCH_ENABLED	T-bit=LOW	STOP

Row 2 — SDR with Regular Read IBI MDB Indicates: REPORT_DATA_AVAILABLE

Open Drain	Open Drain	Open Drain	Hand Off	Push-Pull	Drive High or Low, and then High-Z	I3C SDR			HDR Touch Report 1						I3C HDR
START	Touch_addr_as_IBI/R	Master_ACK	SCL High	MDB	T	Repeated START	Broadcast	Enter HDR ENTRHDR0	HDR Read CMD	Touch Data	....	Touch Data	CRC	HDR Exit	STOP

…. Continues Touch Slave Device touch report generation ….

Row 3 — SDR with Regular Read IBI MDB Indicates: REPORT_DATA_AVAILABLE

Open Drain	Open Drain	Open Drain	Hand Off	Push-Pull	Drive High or Low, and then High-Z	I3C SDR			HDR Touch Report 1						I3C HDR
START	Touch_addr_as_IBI/R	Master_ACK	SCL High	MDB	T	Repeated START	Broadcast	Enter HDR ENTRHDR0	HDR Read CMD	Touch Data	....	Touch Data	CRC	HDR Exit	STOP

Row 4 — De-activate TOUCH_EN

Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull		Push-Pull		
START	I3C Reserved Byte/W (7'h7E/W)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave_ACK	Write mtcs_set_get_configuration Addr/W	T	Write touch_en = TOUCH_ENABLED	T-bit=LOW	STOP

Legend:
- From Master to Slave
- From Slave to Master
- Transition Bit (Parity bit for WRITE)
- Transition Bit (End-of-Data for READ DATA)

Return

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SDR Regular Read

#	Mode											
1	**Activate TOUCH_EN**	Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull		Push-Pull		
		START	I3C Reserved Byte/W (7'h7E/W)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave_ACK	Write mtcs_set_get_configuration Addr/W	T	Write **touch_en** = TOUCH_ENABLED	T	STOP
2	**SDR with Regular Read IBI MDB Indicates: REPORT_DATA_AVAILABLE**	Open Drain	Open Drain	Open Drain	Hand Off	Push-Pull		Bus MUST be available between STOP and START				
		START	Touch_SLAVE_addr_as_IBI/R	Master ACK	T	MDB	T					
3	**Configure private read for mtcs_read_touch_report (8'h40)**	Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull			Bus MUST be available between STOP and START	
		START	I3C Reserved Byte/W (7'h7E/W)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave ACK	Write mtcs_read_report 8'h40/W	T	STOP		
4	**Read touch report**	Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	**SDR Touch Report**				
		START	I3C Reserved Byte/R (7'h7E/R)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/R	Slave ACK	Touch Data	....	Touch Data	T	STOP
	LOOP BACK TO #2											
5	**De-activate TOUCH_EN**	Open Drain	Open Drain	Open Drain	Open Drain	Push-Pull	Open Drain	Push-Pull		Push-Pull		
		START	I3C Reserved Byte/W (7'h7E/W)	Slave ACK	Repeated START	I3C Dynamic Slave Addr/W	Slave ACK	Write mtcs_set_get_configuration Addr/W	T	Write **touch_en** = TOUCH_DISABLED	T	STOP

Legend:
- From Master to Slave
- From Slave to Master
- Transition Bit (Parity bit for WRITE)
- Transition Bit (End-of-Data for READ DATA)

Information ONLY - Please refer to full technical standard – Not to be used in a standard. This is not a Specifications contribution.

MIPI Interrupt Type Handling Register

Name: mtcs_get_interrupt_type		
Command Description: Returns interrupt type		
Access: Read Only		
Default Value: 00h		
Offset:00h		
Bit	Field Name	Brief Description
4:0	interrupt_type [4:0]	5'd0: NO_INTERRUPT_PENDING 5'd1: REPORT_DATA_AVAILABLE 5'd2: COMMAND_DONE 5'd3: ERROR_OCCURRED 5'd4: REPORT_DATA_AVAILABLE_END_OF_FRAME 5'D5-5'D15: RESERVED 5'D16-5'D31: MANUFACTURER_DEFINED
7:5	Reserved	

Offset:01h		
0	operational_status	1'b0: NOT_READY_FOR_OPERATION 1'b1: READY_FOR_OPERATION
1	configuration_status	1'b0: CONFIGURATION_DATA_WRITE_NO_REQUEST 1'b1: CONFIGURATION_DATA_WRITE_REQUEST
2	fatality_status	1'b0: NON_FATAL_ERROR 1'b1: FATAL_ERROR
3	invalid_firmware_error	1'b0: VALID_FIRMWARE 1'b1: INVALID_FIRMWARE_ERROR
4	invalid_configuration_data_error	1'b0: VALID_CONFIGURATION_DATA 1'b1: INVALID_CONFIGURATION_DATA_ERROR
5	self_test_failed_error	1'b0: SELF_TEST_PASSED 1'b1: SELF_TEST_FAILED_ERROR
6:7	Reserved	

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