



# FPGA Interface Manager Data Sheet

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**Intel® Programmable Acceleration Card with  
Intel® Arria® 10 GX FPGA**



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## 1. Overview

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The FPGA Interface Manager (FIM) data sheet provides the key parameters to which you must design your Accelerator Functional Unit (AFU).

The FIM consists of the following:

- FPGA Interface Unit (FIU): The platform interface layer that acts as a bridge between PCIe\* and Core Cache Interface (CCI-P).
- Core Cache Interface (CCI-P): standard interface AFUs use to communicate with the host.
- External Memory Interface (EMIF)
- High-Speed Serial Interface (HSSI) for external transceivers

Each of these components have parameter values that must be met by the AFU.

## 2. FIM and AFU Parameter Data

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Use the following tables in conjunction with the *Accelerator Functional Unit (AFU) Developer's Guide* and the *Intel® Acceleration Stack for Intel Xeon® CPU with FPGAs Core Cache Interface (CCI-P) Reference Manual* to complete your AFU design.

### Related Information

- [Accelerator Functional Unit Developer's Guide](#)
- [Intel Acceleration Stack for Intel Xeon CPU with FPGAs Core Cache Interface \(CCI-P\) Reference Manual](#)

### 2.1. Memory Interface

The Intel FPGA PAC with Intel Arria® 10 GX FPGA features two DDR4 SDRAM memory banks, each of 4 GB capacity. They can be used by the AFU as a local workspace for large datasets. Each bank can be accessed independently by the AFU. Each memory bank interface is 64-bits and operates at 1066 MHz DDR.

**Table 1. Local Memory Interface Specifications**

Parameter	Value
Memory Protocol	DDR4-SDRAM
AFU Interface Type	Avalon™ Memory Mapped Interface (Avalon-MM)
Number of Memory Interfaces	2
Density per Memory Interface	4 GB
AFU-Accessible Memory Address Bus Width	27-bit
AFU-accessible Memory Data Width	512-bit
Interface Frequency	266 MHz
Maximum Burst Size	64 beats
Address Mapping	CS-CID-Row-Bank-Col-BG

#### 2.1.1. SDRAM Signals

This table defines the interface for each of the two DDR4 memories from the viewpoint of the AFU.

**Table 2. SDRAM Interface**

Signal Name	Direction (AFU viewpoint)	Width	Description
clk	input	1	Provides synchronization for internal logic.
waitrequest	input	1	Asserts when the EMIF controller is unable to respond to a read or write request.
readdata	input	512	Read data signal from the DDR4 to the AFU.
readdatavalid	input	1	Used for variable-latency, pipelined read transfers. When asserted, indicates that the readdata signal contains valid data.
burstcount	output	7	Used to indicate the number of transfers in each burst.
writedata	output	512	Write data signal to the external DDR4.
address	output	27	By default, the interconnect translates the byte address into a word address in the slave's address space. From the perspective of the slave, each slave access is for a word of data.
write	output	1	Asserted to indicate a write transfer.
read	output	1	Asserted to indicate a read transfer.
byteenable	output	64	Enables one or more specific byte lanes during transfers on interfaces of width greater than 8 bits. Each bit in byteenable corresponds to a byte in writedata and readdata.

## 2.2. Core Cache Interface (CCI-P) Interface

**Table 3. Core Cache Interface (CCI-P) Specifications**

Parameter	Value	Notes
Data Width	512-bit	CCI-P interface width.
Maximum CCI-P Frequency	pClk	-
Host Memory Cache-Line Size	64-byte	-
MMIO access width	32-bit and 64-bit	64-bit accesses are mandatory for Device Feature Header (DFH) enumeration.
MMIO Read Response Timeout	65536 clock cycles	-
Virtual Channels Supported	VH0, VA	Accesses to VH0 and VA are mapped to the PCIe link. Accesses to VH1 or VL0 are mapped to VH0.

## 2.3. Clocks

**Table 4. Clock Specifications**

Parameter	Value	Notes
pClk	200 MHz	Primary interface clock. All CCI-P interface signals are synchronous to this clock.
pClkDiv2	100 MHz	Synchronous and in phase with pClk. 0.5x the pClk clock frequency.
pClkDiv4	50 MHz	Synchronous and in phase with pClk. 0.25x the pClk clock frequency.
uClk	312.5 MHz	This clock can be adjusted by OPAE.
uClk/2	156.25 MHz	This clock can be adjusted by OPAE.
uClk_usr Min	10 MHz	Minimum user-defined clock. This clock is not synchronous with the pClk. You can adjust this clock using OPAE.
uClk_usr Default	312.5 MHz	Default user-defined clock. This clock is not synchronous with the pClk. You can adjust this clock using OPAE.
uClk_usr Max	600 MHz	Minimum user-defined clock. This clock is not synchronous with the pClk. You can adjust this clock using OPAE.
uClk_usrDiv2 Min	10 MHz	Minimum user defined clock that is synchronous with uClk_usr and 0.5x the frequency. <i>Note:</i> You can use OPAE to set the frequency to a value that is not synchronous with the uClk_usr.
uClk_usrDiv2 Default	156.25 MHz	User defined clock that is synchronous with uClk_usr and 0.5x the frequency. <i>Note:</i> You can use OPAE to set the frequency to a value that is not synchronous with the uClk_usr.
uClk_usrDiv2 Max	600 MHz	Maximum user defined clock that is synchronous with uClk_usr and 0.5x the frequency. <i>Note:</i> You can use OPAE to set the frequency to a value that is not synchronous with the uClk_usr.

## 2.4. Reset

**Table 5. Reset Specifications**

Subsystem	Parameter	Value	Notes
Resets	Min Reset Width	512 pClk cycles	Minimum number of pClk clock cycles the FIM holds the AFU in reset.

## 2.5. Networking Interface

The networking interface provides one QSFP that can be configured to 4x10 GbE or 40 GbE.

**Table 6. Network Interface Specifications**

Parameter	Value	Notes
Rate Supported	8x10GbE or 40 GbE	-
Layers Supported	PHY	Physical Coding Sublayer (PCS) + Physical Medium Attachment (PMA) Sublayer

**Note:** For more information about the Networking Interface for the Intel Programmable Acceleration Card with Intel Arria 10 GX FPGA, please refer to the *Networking Interface for Open Programmable Acceleration Engine: Intel Programmable Acceleration Card with Intel Arria 10 GX FPGA*.

**Related Information**

[Networking Interface for Open Programmable Acceleration Engine: Intel Programmable Acceleration Card with Intel Arria 10 GX FPGA](#)

**2.5.1. Clock Signals**

The clocks of the partial reconfiguration (PR) HSSI Interface synchronize the unified data interface between the MAC IP and the HSSI PHY. The signal directions listed for HSSI ports are from the perspective of the FIM. The signals listed below are identical for both QSFP28 interfaces.

**Table 7. Clock Signals**

Port Name	Width	Direction	Description
f2a_tx_clk	1	Output	<b>4x10GBASE-R Mode:</b> A 156.25 MHz clock derived from the HSSI PHY's clock generation block (CGB) tx_pma_div_clkout clock output. All transmit data and control from the MAC to the HSSI PHY is synchronous to f2a_tx_clk. <b>40GBASE-SR4 Mode:</b> A 312.5 MHz clock derived from the HSSI PHY's CGB tx_pma_div_clkout clock output. All transmit data and control from the MAC/PHY to the HSSI PHY is synchronous to f2a_tx_clk.
f2a_tx_clkx2	1	Output	<b>4x10GBASE-R Mode:</b> A 312.5 MHz clock derived from the HSSI PHY's CGB tx_pma_div_clkout clock output and phase-aligned with f2a_tx_clk. <b>40GBASE-SR4 Mode:</b> A 312.5 MHz clock derived from the PHY's CGB tx_pma_div_clkout clock output and phase-aligned with f2a_tx_clk.
f2a_tx_locked	1	Output	<b>4x10GBASE-R Mode:</b> Locked status for f2a_tx_clk and f2a_tx_clkx2. <b>40GBASE-SR4 Mode:</b> Locked status for f2a_tx_clk and f2a_tx_clkx2.
f2a_rx_clk_ln0	1	Output	<b>4x10GBASE-R Mode:</b> A 156.25 MHz clock derived from the HSSI PHY's transmitter and receive CDR PLL clock input reference. All receive data and control from the HSSI PHY to the MAC is synchronous to f2a_rx_clk_ln0. <b>40GBASE-SR4 Mode:</b> A 312.5 MHz clock derived from the HSSI PHY's receive CDR in lane 0. All receive data and control from the HSSI PHY to the MAC/PHY is synchronous to f2a_rx_clk_ln0.

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Port Name	Width	Direction	Description
f2a_rx_clkx2_ln0	1	Putput	<b>4x10GBASE-R Mode:</b> A 312.5 MHz clock derived from the HSSI PHY's transmitter and receive CDR PLL clock input reference and phase-aligned with f2a_rx_clk_ln0. <b>40GBASE-SR4 Mode:</b> A 312.5 MHz clock derived from the HSSI PHY's receive CDR in lane 0 and phase-aligned with f2a_rx_clk_ln0.
f2a_rx_locked_ln0	1	Output	<b>4x10GBASE-R Mode:</b> Locked status for f2a_rx_clk_ln0 and f2a_rx_clkx2_ln0. <b>40GBASE-SR4 Mode:</b> Locked status for f2a_rx_clk_ln0 and f2a_rx_clkx2_ln0.
f2a_rx_clk_ln4	1	Output	<b>4x10GBASE-R Mode:</b> Reserved <b>40GBASE-SR4 Mode:</b> Reserved
f2a_rx_locked_ln4	1	Output	<b>4x10GBASE-R Mode:</b> Reserved <b>40GBASE-SR4 Mode:</b> Reserved

### 2.5.2. Data Interface and Signals

The HSSI unified data interface conforms to the Intel Arria 10 FPGA Transceiver Native PHY IP with enhanced PCS. It consists of generic parallel data and encoding control interfaces for transmit and receive that are mapped to specific signaling behavior based on the configured HSSI PHY mode. The unified data interface also includes flow control ports to manage passing data to and from the HSSI PHY.

The below table provides a cross reference from the `hssi:raw_pr` unified data interface signals to the Intel Arria 10 FPGA Transceiver Native PHY IP with enhanced PCS signal set. For detailed information on these signals, see the [Intel Arria 10 Transceiver PHY User Guide](#) as referenced in the below table.

**Table 8. Data Signals**

Port Name	Width	Direction	Clock Domain	Native PHY IP Port Name
<b>Transmit and Receive Data and Encoding Control Ports</b>				
a2f_tx_parallel_data	(4*128)	Input	f2a_tx_clk	tx_parallel_data
a2f_tx_control	(4*18)	Input	f2a_tx_clk	tx_control
f2a_rx_parallel_data	(4*128)	Output	f2a_rx_clk_ln0	rx_parallel_data
f2a_rx_control	(4*20)	Output	f2a_rx_clk_ln0	rx_control
<b>Flow Control Ports</b>				
f2a_tx_enh_fifo_full	4	Output	f2a_tx_clk	tx_enh_fifo_full
f2a_tx_enh_fifo_pfull	4	Output	f2a_tx_clk	tx_enh_fifo_pfull
f2a_tx_enh_fifo_empty	4	Output	f2a_tx_clk	tx_enh_fifo_empty
f2a_tx_enh_fifo_pempty	4	Output	f2a_tx_clk	tx_enh_fifo_pempty
a2f_tx_enh_data_valid	4	Input	f2a_tx_clk	tx_enh_data_valid
f2a_rx_enh_fifo_full	4	Output	f2a_rx_clk_ln0	rx_enh_fifo_full
f2a_rx_enh_fifo_pfull	4	Output	f2a_rx_clk_ln0	rx_enh_fifo_pfull
<i>continued...</i>				



Port Name	Width	Direction	Clock Domain	Native PHY IP Port Name
f2a_rx_enh_fifo_empty	4	Output	f2a_rx_clk_ln0	rx_enh_fifo_empty
f2a_rx_enh_fifo_pempty	4	Output	f2a_rx_clk_ln0	rx_enh_fifo_pempty
f2a_rx_enh_data_valid	4	Output	f2a_rx_clk_ln0	rx_enh_data_valid
a2f_rx_enh_fifo_rd_en	4	Input	f2a_rx_clk_ln0	rx_enh_fifo_rd_en
f2a_rx_enh_fifo_pempty	4	Output	f2a_rx_clk_ln0	rx_enh_fifo_pempty
f2a_rx_enh_data_valid	4	Output	f2a_rx_clk_ln0	rx_enh_data_valid
a2f_rx_enh_fifo_rd_en	4	Input	f2a_rx_clk_ln0	rx_enh_fifo_rd_en

### 2.5.3. Control and Status Signals

This set of ports on the `hssi` interface provide for HSSI PHY receive Physical Medium Attachment (PMA) clock data recovery (CDR) lock sequencing control, PCS status, and transceiver loopback control. The signaling behavior conforms to the Intel Arria 10 FPGA Transceiver Native PHY IP with enhanced PCS. The below table cross references the `hssi` port names to the Native PHY IP port names.

**Table 9. Control and Status Signals**

Port Name	Width	Direction	Clock Domain	Native PHY IP Port Name
a2f_rx_serialpbken	4	Input	Async	rx_serialpbken
a2f_rx_set_locktoref	4	Input	Async	rx_set_locktoref
f2a_rx_is_lockedtoref	4	Output	Async	rx_is_lockedtoref
a2f_rx_set_locktodata	4	Input	Async	rx_set_locktodata
f2a_rx_enh_blk_lock	4	Output	f2a_rx_clk_ln0	rx_enh_blk_lock
f2a_rx_enh_highber	4	Output	f2a_rx_clk_ln0	rx_enh_highber

### 3. FPGA Interface Manager (FIM) Resource Utilization

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**Table 10. FPGA Core Fabric Resource Utilization by the FIM**

Parameter	FIM Utilization Total	Device Total	Percentage of Resources Used by FIM	Notes
ALMs	33,686	427,200	8%	Adaptive Logic Modules blocks.
M20Ks	126	2713	5%	Memory blocks with 20K bits.
DSPs	0	1518	0%	Digital Signal Processing blocks.

## 4. Document Revision History for FPGA Interface Manager Data Sheet: Intel Programmable Acceleration Card with Intel Arria 10 GX FPGA

Document Version	Acceleration Stack Version	Changes
2021.08.18	1.2.1 (compatible with Intel Quartus® Prime Pro Edition 19.2)	Clarified description in section: <i>SDRAM Signals</i> .
2020.06.03	1.2.1 (compatible with Intel Quartus Prime Pro Edition 19.2)	Added the <i>Address Mapping</i> parameter in Table: <i>Local Memory Interface Specifications</i> .
2020.03.06	1.2.1 (compatible with Intel Quartus Prime Pro Edition 19.2)	Initial Release

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