GW5AT Series of FPGA Products

Data Sheet

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Revision History

Date	Version	Description
3/14/2024	1.0E	Preliminary version.
6/14/2024	1.0E	Initial version published.
6/28/2024	1.0.1E	Power supply names unified.
7/18/2024	1.0.2E	BSRAM description optimized.
9/13/2024	1.0.3E	AC/DC characteristics optimized.
11/08/2024	1.0.4E	MIPI C-PHY characteristics added.
11/29/2024	1.0.5E	Speed grade descriptions unified; Figure 4-2 modified.
12/31/2024	1.0.6E	• Transfer rates optimized for the soft MIPI D-PHY RX/TX implemented by the MIPI IO type. • New packages added: GW5AT-60 UG225H and GW5AT-60 UG324A.
01/17/2025	1.0.7E	• MIPI D-PHY Characteristics updated. • Power Supply Ramp Rates updated. • The MIPI C-PHY RX Fmax description of the GW5AT-LV60UG225H device added.

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1 Product Overview

GW5AT Series of FPGA Products are the 5 series products of Arora family, with abundant internal resources, a new-architecture and high-performance DSP supporting AI operations, high-speed LVDS interfaces, and abundant BSRAM resources. At the same time, it integrates self-developed DDR3, 12.5Gbps SERDES supporting multiple protocols, and provides a variety of packages. It is suitable for applications such as low power, high performance and compatibility designs.

GOWINSEMI provides a new generation of FPGA hardware development environment that supports FPGA placement & routing, bitstream generation and download, etc.

1.1 Features

- Lower power consumption
  - 22nm SRAM process
  - Core Power(LV version): 0.9V/1.0V
  - Core voltage(EV version): 1.2V
  - Supports dynamic on/off of clock
- Abundant logic cells
  - Provides up to 15.1K~ 138K LUT4s
  - Supports shadow SRAMs
- Block SRAMs with multiple modes
  - Supports Dual Port, Single Port, Semi Dual Port, and ROM
  - Supports bytes write enable
  - Supports ECC detection and error correction
- Supports multiple transmission protocols such as 270 Mbps to 12.5 Gbps custom SERDES protocols and 10G Ethernet, etc.
- Supports PCIe 3.0 hard core
  - Supports x1, x2, x4, x8 lanes
  - Supports End Point
- High performance DSP blocks with a new architecture
  - Supports 27x18, 12x12, 27x36 multiplier and 48-bit accumulator
  - Supports cascading of multipliers
  - Supports pipeline mode and bypass mode
  - Pre-addtion operation for filter function
  - Supports barrel shifter

- A new and flexible X-channel oversampling ADC with high accuracy, no external voltage source required
- Supports MIPI D-PHY RX/TX hardcore
  - Supports MIPI DSI and MIPI CSI-2 RX
  - Up to 2.5 Gbps per MIPI lane
  - Supports up to eight data lanes and two clock lanes, with the max. transmission speed up to 20 Gbps
- Supports MIPI C-PHY RX/TX hardcore
  - One MIPI Quad supports up to 3-trios data lanes and supports up to RX/TX data rate per lanes
- GPIO supports MIPI D-PHY RX (MIPI IO)
  - GPIO can be configured as MIPI DSI and MIPI CSI-2 RX/TX interfaces
  - Up to 2.0 Gbps per MIPI lane for MIPI D-PHY RX/TX
- GPIO supports MIPI C-PHY RX/ MIPI IO
- Supports various SDRAM interfaces, up to DDR3 1333 Mbps
- Multiple I/O standards
  - Hysteresis option for input signals
  - Supports drive strengths of 2mA, 4mA, 6mA, 8mA, 12mA, 16mA, 24mA,etc.
  - Individual Bus Keeper, Pull-up, Pull-down, and Open Drain options
  - Hot Socket
- 16 global clocks, 12/8/2 high-performance PLLs, 24/20/2 high speed clocks
- MIPI D-PHY, MIPI C-PHY, PLL, and ADC modules support Mini Dynamic Re-Program Port (mDRP)
- Configuration & Programming
  - JTAG configuration
  - Four GowinConfig configuration: SSPI, MSPI, Master CPU, Slave CPU, Master SERIAL, Slave SERIAL, and PCIe
  - Supports programming the SPI Flash directly in JTAG and SSPI modes; For other modes, you can program the SPI Flash using the IP
  - Supports background upgrade
  - Supports bitstream file encryption and security bit settings
  - Supports Configuration Memory Soft Error Recovery (CMSER)
  - Supports OTP, a unique 64-bit DNA identifier for each device

1.2 Product Resources

Table 1-1 GW5AT series of FPGA Products Information List

Device	GW5AT-15	GW5AT-60	GW5AT-75	GW5AT-138
LUT4	15120	59904	86688	138240
Flip-Flop (REG)	15120	59904	86688	138240
Shadow Static Random Access Memory (SSRAM) (Kb)	118.125	468	677	1080
Block Static Random Access Memory (BSRAM) (Kb)	630	2124	4608	6120
Number of BSRAMs	35	118	256	340

Device	GW5AT-15	GW5AT-60	GW5AT-75	GW5AT-138
DSP (27-bit x 18-bit)	28	118	213	298
DSP Lite	12	-	-	-
Maximum phase locked loop[1] (PLLs)	2	8	12	12
Global Clocks	16	16	16	16
High-speed Clocks	2	20	24	24
Transceivers[2]	4	4	8	8
Transceivers Rate[3]	270Mbps - 12.5Gbps	270Mbps - 12.5Gbps	270Mbps - 12.5Gbps	270Mbps - 12.5Gbps
PCIe 3.0	1, x1, x2, x4 PCIe 3.0	1, x1, x2, x4 PCIe 3.0	1, x1, x2, x4, x8 PCIe 3.0	1, x1, x2, x4, x8 PCIe 3.0
LVDS Gbps	1.25	1.25	1.25	1.25
DDR3 Mbps	–	1333	1333	1333
MIPI D-PHY hardcore[5]	2.5Gbps (RX/TX), 4 data lanes 1 clock lane	2.5Gbps (RX/TX), 4 data lanes 1 clock lane	2.5Gbps (RX) 8 data lanes 2 clock lane	2.5Gbps (RX) 8 data lanes 2 clock lane
MIPI C-PHY Hardcore	2.5Gsps (RX/TX), 3-trios data lanes	2.5Gsps (RX/TX), 3-trios data lanes	-	-
ADC	1	2	2	2
Number of GPIO banks	4	11	6	6
Maximum number of GPIOs[4]	53	320	312	312
Core voltage	0.9V/1.0V	0.9V/1.0V/1.2V	0.9V/1.0V	0.9V/1.0V

Note!

- [1] Different packages support different numbers of PLLs, and here is the max. number.
- [2] Different packages support different numbers of Transceivers, and here is the max. number.
- [3] The maximum rate that a Transceiver can support depends on the packages.
- [4] This is the max. number of GPIOs that the device can provide without package limitation. Please refer to Table 1-2, Table 1-3, Table 1-4, and Table 1-5 for the maximum number of user I/O available in specific packages.
- [5] MIPI D-PHY support and the number of channels vary depending on the package, with the maximum values listed here.

Table 1-2 GW5AT-138 Package Information

Package			Pitch (mm)	Size (mm)	GW5AT-138		
Name	Type	Description			User I/O (True LVDS Pair)	Transceivers[1]	MIPI D- PHY Hard-core
FPG676A	FCPBGA	Flip Chip	1.0	27 x 27	311(150)	8	RX 8 data lanes 2 clock lanes
PG676A	PBGA	Wire Bond	1.0	27 x 27	311(150)	8	RX 8 data lanes 2 clock lanes
PG484A	PBGA	Wire Bond	1.0	23 x 23	291(143)	4	–
PG484	PBGA	Wire Bond	1.0	23 x 23	271(133)	4	RX 8 data lanes 2 clock lanes
UG324A	UBGA	Wire Bond	0.8	15x15	141(68)	4	RX 8 data lanes 2 clock lanes

Note!

- [1] Transceivers in the PBGA/UBGA package can reach speeds up to 10.3125 Gbps, and when the rate exceeds 8 Gbps, only on-board interconnects are supported, not backplane applications.
- [1] Transceivers in the FCPBGA package can reach speeds up to 12.5 Gbps.

Table 1-3 GW5AT-75 Package Information

Package			Pitch (mm)	Size (mm)	GW5AT-75		
Name	Type	Description			User I/O (True LVDS Pair)	Transceivers[1]	MIPI D- PHY Hard-core
UG484	UBGA	Wire Bond	0.8	19x19	311(150)	8	RX 8 data lanes 2 clock lanes

Note!

[1] Transceivers can reach speeds up to 10.3125 Gbps, and when the rate exceeds 8 Gbps, only on-board interconnects are supported, not backplane applications.

Table 1-4 GW5AT-60 Package Information

Package			Pitch (mm)	Size (mm)	GW5AT-60			
Name	Type	Description			User I/O (True LVDS Pair)	Transceivers[1]	MIPI D- PHY Hard-core	MIPI C- PHY Hard-core
PG484A	PBGA	Wire Bond	1.0	23x23	297(143)	4	–	–
UG225	UBGA	Wire Bond	0.8	13x13	113(53)	4	RX/TX 4 data lanes 1 clock lane	RX/TX 3-trios data lanes
UG225H	UBGA	Wire Bond	0.8	13x13	113(53)	4	RX/TX 4 data lanes 1 clock lane	RX/TX 3-trios data lanes
UG324A	UBGA	Wire Bond	0.8	15x15	162(76)	4	–	–
UG324S	UBGA	Wire Bond	0.8	15x15	198(98)	4	–	–

Note!

[1] Transceivers can reach speeds up to 10.3125 Gbps, and when the rate exceeds 8 Gbps, only on-board interconnects are supported, not backplane applications.

Table 1-5 GW5AT-15 Package Information

Package			Pitch (mm)	Size (mm)	GW5AT-15			
Name	Type	Description			I/O (True LVDS Pair)	Transceivers[1]	MIPI D- PHY Hard-core	MIPI C- PHY Hard-core
MG132	MBGA	Wire Bond	0.5	8x8	53(25)	4	RX/TX 4 data lanes 1 clock lane	RX/TX 3-trios data lanes
CS130	WLCSP	Wire Bond	0.4	4.0x5.3	53(25)	4	RX/TX 4 data lanes 1 clock lane	RX/TX 3-trios data lanes

Note!

[1] Transceivers can reach speeds up to 10.3125 Gbps, and when the rate exceeds 8 Gbps, only on-board interconnects are supported, not backplane applications.

2 Architecture

2.1 Architecture

Figure 2-1 Architecture Diagram (GW5AT-138)

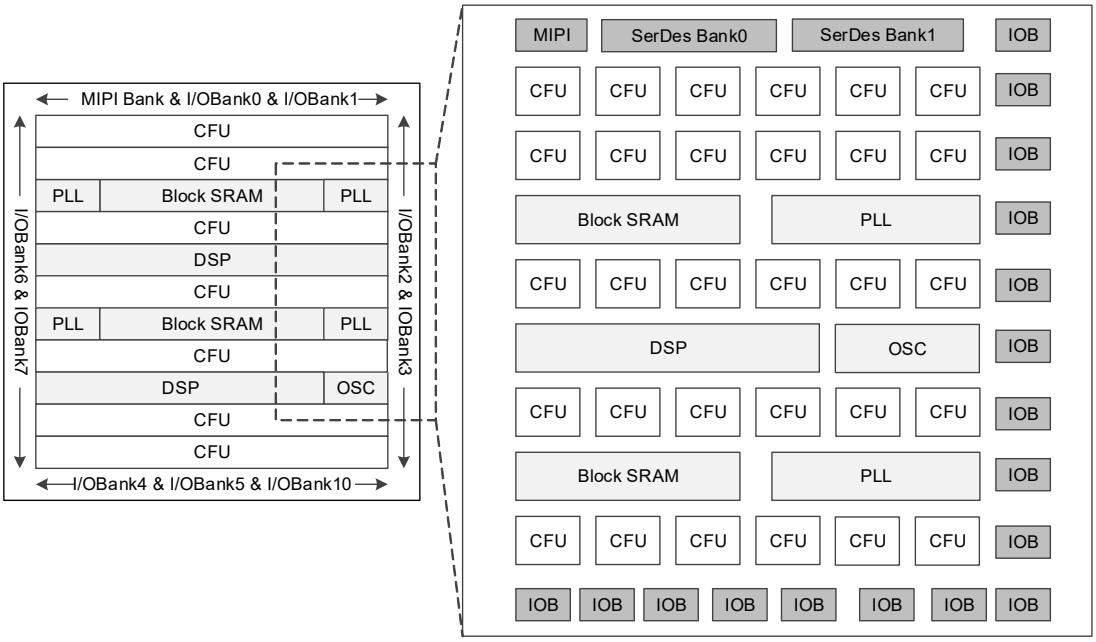


Figure 2-2 Architecture Diagram (GW5AT-75)

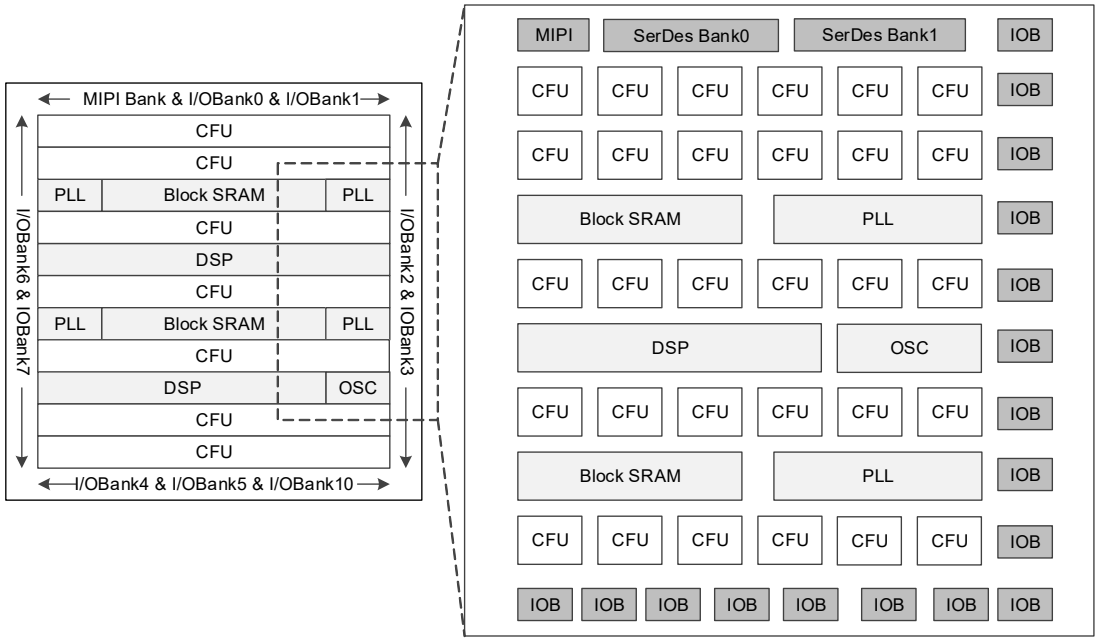


Figure 2-3 Architecture Diagram (GW5AT-60)

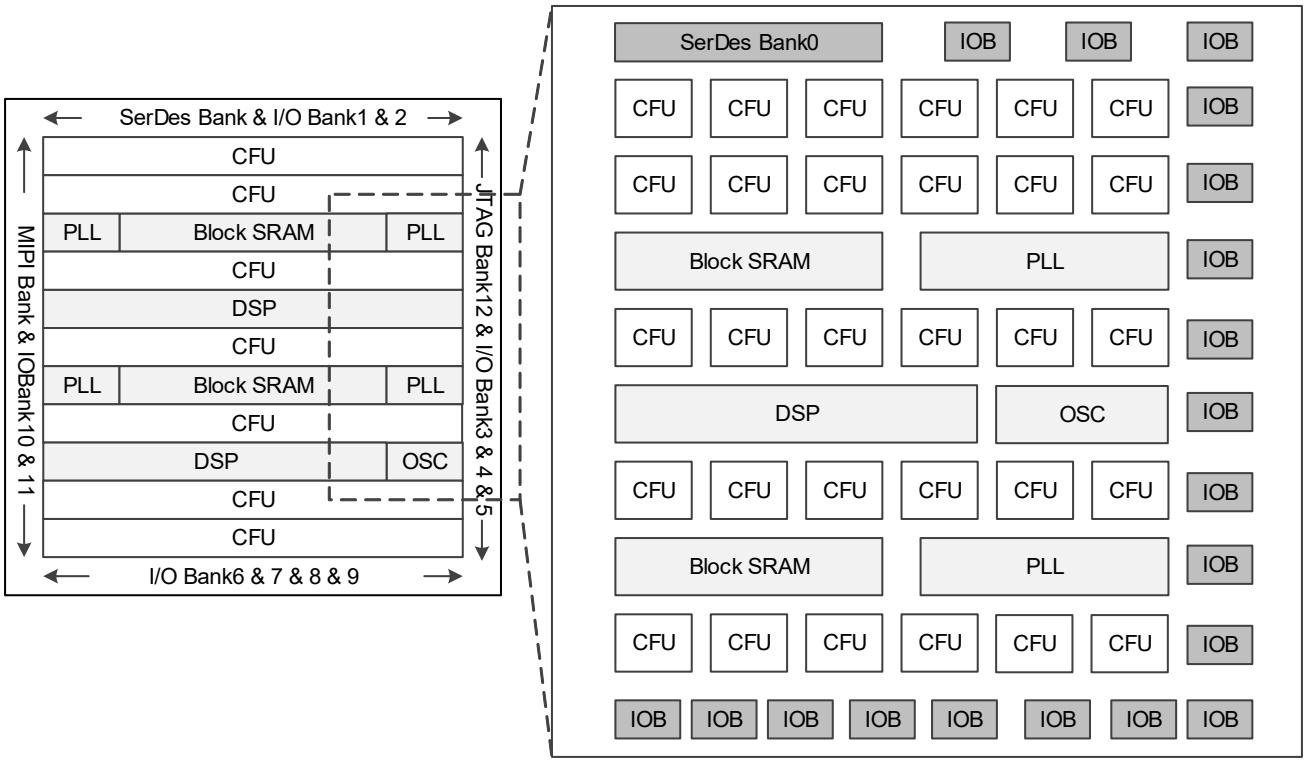


Figure 2-4 Architecture Diagram (GW5AT-15)

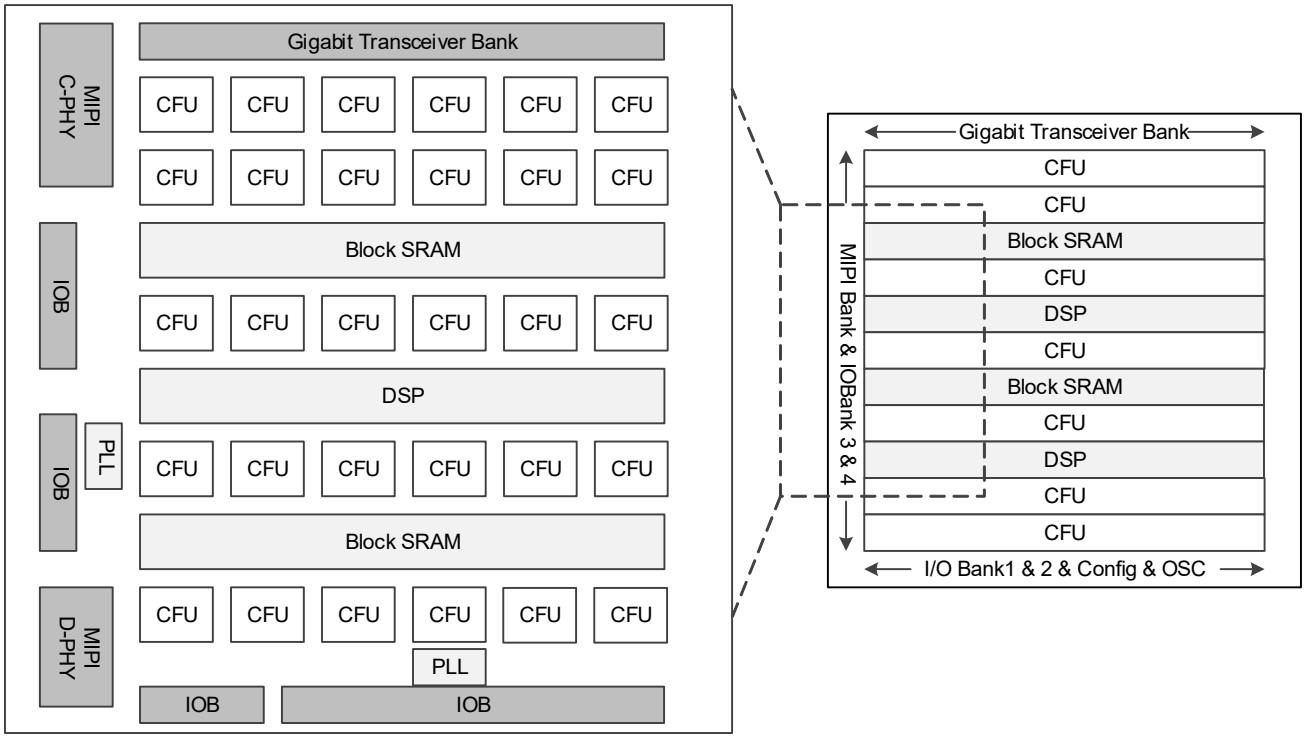


Figure 2-1 is the architecture overview of the GW5AT-138 devices.

Figure 2-2 is the architecture overview of the GW5AT-75 devices.

Figure 2-3 is the architecture overview of the GW5AT-60 devices.

Figure 2-4 is the architecture overview of the GW5AT-15 devices.

The core of the GW5AT Series of FPGA Products is an array of Configurable Function Units (CFU) surrounded by IO blocks. Besides, BSRAMs, DSP blocks, MIPI D-PHY, ADC, PLLs, and on chip oscillators are supported. For the internal resource information, please refer to Table 1.

Configurable Function Unit (CFU) is the base cell for the array of the Products. Devices with different capacities have different numbers of rows and columns. CFU can be configured as LUT4 mode, ALU mode, and memory mode. For more detailed information, see *2.2 Configurable Function Units*.

The I/O resources in are arranged around the periphery of the devices in groups referred to as banks. I/O resources support multiple I/O standards, and support regular mode, SRD mode, generic DDR mode, and DDR_MEM mode. For more detailed information, see *2.3 Input/Output Block*.

The BSRAM is embedded as a row in the products and supports multiple configuration modes and operation modes. For more detailed information, see *2.4 Block SRAM*.

GW5AT Series of FPGA Products are embedded with a brand-new DSP, which can meet the your high-performance digital signal processing requirements DSP. For further details, refer to *2.5 DSP*.

GW5AT Series of FPGA Products support 12.5Gbps SERDES with multiple protocols. For further details, please refer to *2.6 Gigabit Transceiver* and *2.7 PCI Express (PCIe) Controller* for details.

GW5AT Series of FPGA Products provide a MIPI D-PHY hardcore supporting the “MIPI Alliance Standard for D-PHY Specification(V1.2)”. For details, see *2.8 MIPI D-PHY*.

GW5AT-15 / GW5AT-60 devices contain a hard core MIPI C-PHY, see *2.9 MIPI C-PHY* for details.

GW5AT Series of FPGA Products integrates different types of ADCs. Please refer to *2.10 ADC* for details.

GW5AT Series of FPGA Products have embedded PLL resources. PLL blocks provide the ability to synthesize clock frequencies. Frequency adjustment (multiply and division), phase adjustment, and duty cycle can be adjusted using the configuration of parameters . The FPGAs also have an embedded programmable on-chip clock oscillator that supports clock frequencies ranging from 1.67 MHz to 105MHz, providing clocking resources for the MSPI mode. The on-chip clock oscillator also provides programmable user clocks. For more information, see *2.11 Clock and 2.14 On Chip Oscillator.*

FPGA provides abundant CRUs, connecting all the resources in FPGA. For example, routing resources distributed in CFU and IOB connect the internal resources of the CFU to the logical resources inside the IOB. Routing resources can automatically be generated by Gowin software. In addition, GW5AT Series of FPGA Products also provide abundant GCLKs, long wires (LW), global set/reset (GSR), and programming options, etc. For more details, see *2.12 Global Reset* and *2.13 Programming Configuration*.

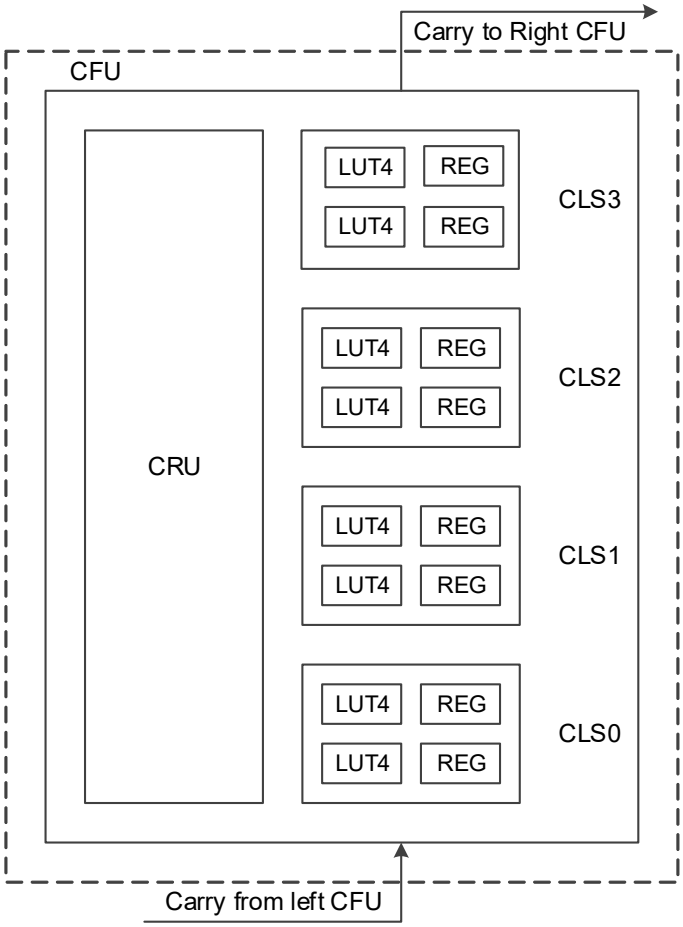
2.2 Configurable Function Units

Configurable Function Units (CFUs) are the basic cells for the array of GOWINSEMI FPGA Products. Each basic cell consists of four Configurable Logic Sections (CLSs) and their routing resource Configurable Routing Units (CRUs). Each CLS includes two 4 input look-up-tables (LUTs) and two registers (REGs), as shown in Figure 2-5.

CLSs in the CFUs can be configured as basic look-up tables, arithmetic logic units, static random access memories, and read only memories according to application scenarios.

For more details, please see *UG303, Arora V Configurable Function Unit (CFU) User Guide*.

Figure 2-5 CFU Structure View



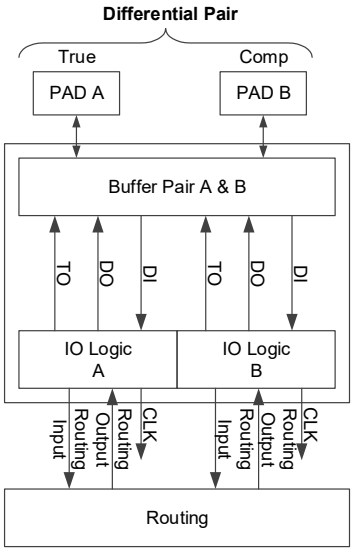
2.3 Input/Output Blocks

The GPIOs meet a variety of I/O standards and supports both single-ended and differential level standards, providing an easy connection with external buses, storage devices, video applications, and other standards.

The basic units are IOB, including I/O buffer, I/O logic, and the relevant programmable routing unit. The programmable routing unit is similar to the CRU in CFU.

As shown in Figure 2-6, each IOB connects to two Pins (Marked as A and B They can be used as a differential pair or as a single end input/output. The I/O logic supports deserializer, serializer, delay control, and byte alignment, and is suitable for high-speed data transmission. The programmable routing unit is used to inter-connect I/O blocks with other on-chip resources.

Figure 2-6 IOB Structure View



IOB Features:

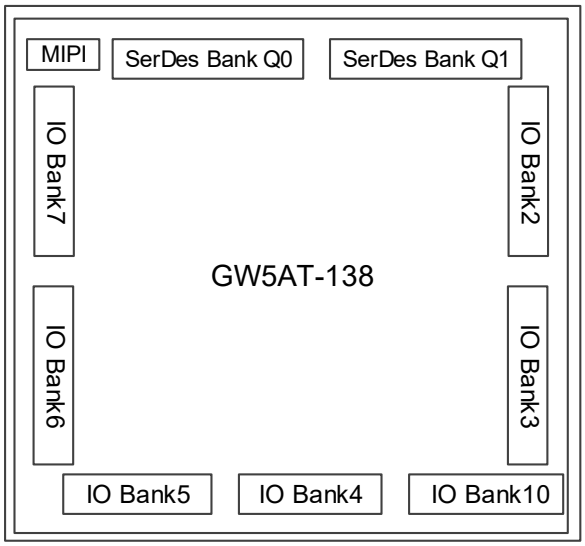
- V_{CCIO} supplied with each bank
- Support multiple levels: LVCMOS, PCI, LVTTL, SSTL, HSTL, LVDS, Mini_LVDS, RSDS, PPDS, BLVDS, etc
- Support MIPI and MIPI I3C OpenDrain/PushPull conversion
- Hysteresis option for input signals
- Output drive strength option
- GW5AT-15 / GW5AT-60 supports slew rate option for output signals
- Individual bus keeper, pull-up/down resistor, and open drain output options
- Hot Socket
- I/O logic supports SDR, DDR, etc.

2.3.1 I/O Buffer

GW5AT-138

GW5AT-138 has six GPIO Banks (Bank2~7), two SerDes Banks and a Bank for configuration (Bank 10), as shown in Figure 2-7. Bank 10 can also be used as an I/O Bank.

Figure 2-7 I/O Bank Distribution View (GW5AT-138)



Each Bank has independent I/O power supply V_{CCIO}. V_{CCIO} can be set as 3.3V, 2.5V, 1.8V, 1.5V, 1.35V, 1.2V, or 1V. The auxiliary voltage V_{CCX} supports 1.8V.

To support SSTL, HSTL, etc., each bank also provides one independent voltage source (VREF) as the reference voltage. You can choose from the internal reference voltage of the bank (0.6V, 0.675V, 0.75V, 0.9V and (33%,42%,50%,58%)V_{CCIO}) or the external reference voltage using any IO from the bank.

Different banks in the support different on-chip resistor settings, including single-ended resistors and differential resistors. Single-ended resistor settings are used for SSTL/HSTL inputs and outputs. Differential resistor settings are used for LVDS/PPDS/ RSDS inputs. For more details, refer to *UG304, Arora V Programmable IO (GPIO) User Guide* .

GW5AT-138 I/O standards and configuration options supported are as listed in Table 2-1 and Table 2-2.

Table 2-1 Output I/O Standards and Configuration Options

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
LVDS25	Differen-tial(TLVDS)	2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
BLVDS25		2.5/3.3	3.5/2.5/4.5/6	Multi-point high-speed data transmission
RSDS		2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
MINILVDS		2.5/3.3	3.5/2.5/4.5/6	LCD timing driver inter-face and column driver interface
PPLVDS		2.5/3.3	3.5/2.5/4.5/6	LCD row/column driver

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
LVDS25E	Differential	2.5	8/4/12/16/24	High-speed point-to-point data transmission
BLVDS25E		2.5	8/4/12/16/24	Multi-point high-speed data transmission
MLVDS25E		2.5	8/4/12/16/24	LCD timing driver interface and column driver interface
RSDS25E		2.5	8/4/12/16/24	High-speed point-to-point data transmission
LVPECL33E		3.3	8/4/12/16/24	Universal interface
HSUL12D		1.2	8/4/12	LPDDR2
HSUL12D_I		1.2	8/4/12	LPDDR2
HSTL15D_I		1.5	8/4/12/16	Memory interface
HSTL15D_II		1.5	8/4/12/16	Memory interface
HSTL18D_I		1.8	8/4/12/16	Memory interface
HSTL18D_II		1.8	8/4/12/16	Memory interface
SSTL135D		1.35	8/4/12	Memory interface
SSTL15D		1.5	8/4/12/16	Memory interface
SSTL18D_I		1.8	8/4/12/16/24	Memory interface
SSTL18D_II		1.8	8/4/12/16/24	Memory interface
LPDDRD		1.8	8/4/12/16/24	LPDDR and Mobile DDR
LVCMOS10D		1.0	4	Universal interface
LVCMOS12D		1.2	4/8	Universal interface
LVCMOS15D		1.5	4/8/12	Universal interface
LVCMOS18D		1.8	4/8/12/16/24	Universal interface
LVCMOS25D		2.5	4/8/12/16/24	Universal interface
LVCMOS33D		3.3	8/4/12/16/24	Universal interface
HSUL12	Single-ended	1.2	8/4/12	Memory interface
HSTL12_I		1.2	8/4/12	Memory interface
HSTL15_I		1.5	8/4/12/16	Memory interface
HSTL15_ II		1.5	8/4/12/16	Memory interface
HSTL18_I		1.8	8/4/12/16/24	Memory interface
HSTL18_II		1.8	8/4/12/16/24	Memory interface
SSTL135		1.35	8/4/12	Memory interface

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
SSTL15	Single-ended	1.5	8/4/12/16	Memory interface
SSTL18_I		1.8	8/4/12/16/24	Memory interface
SSTL18_II		1.8	8/4/12/16/24	Memory interface
LVCMOS10		1.0	4	Universal interface
LVCMOS12		1.2	4/8/12	Universal interface
LVCMOS15		1.5	4/8/12/16	Universal interface
LVCMOS18		1.8	4/8/12/16/24	Universal interface
LVCMOS25		2.5	4/8/12/16/24	Universal interface
LVCMOS33/ LVTTL33		3.3	8/4/12/16/24	Universal interface
LPDDR		1.8	8/4/12/16/24	LPDDR and Mobile DDR
PCI33		3.3	8/4/12/16/24	PC and embedded system

Table 2-2 Input I/O Standards and Configuration Options

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
MIPI	Differential	1.2	No	No
ADC_IN		2.5/1.0/1.2/1.5/1.8/3.3	No	No
LVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
BLVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
RSDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
MINILVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
PPLVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
HSUL12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL12D_I		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL15D_I		1.5/1.0/1.2/1.8/2.5/3.3	No	No
HSTL15D_II		1.5/1.0/1.2/1.8/2.5/3.3	No	No
HSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No
HSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL135D		1.35/1.0/1.2/1.5/1.8/2.5/3.3	No	No
SSTL15D		1.5/1.0/1.2/1.8/2.5/3.3	No	No
SSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No

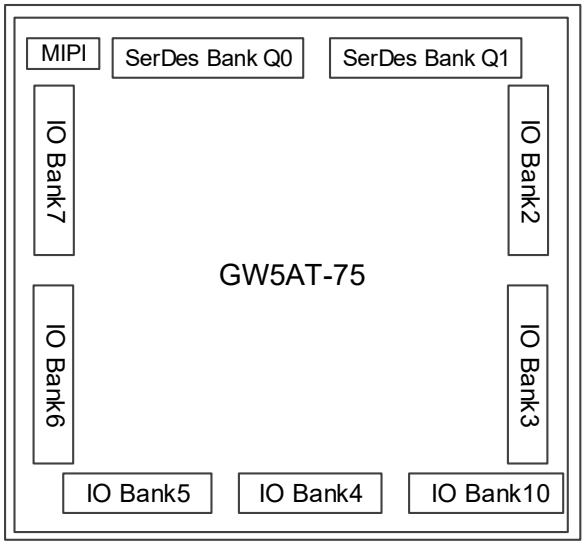
I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
SSTL18D_II	Differential	1.8/1.0/1.2/1.5/2.5/3.3	No	No
LPDDRD		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LVCMOS10D		1.0/1.2/1.5/1.8/2.5/3.3	No	No
LVCMOS12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
LVCMOS15D		1.5/1.0/1.2/1.8/2.5/3.3	No	No
LVCMOS18D		1.8/1.0/1.2/1.5/2.5/3.3	No	No
HSUL12	Single-ended	1.2	No	Yes
HSTL12_I		1.2	No	Yes
HSTL15_I		1.5	No	Yes
HSTL15_II		1.5	No	Yes
HSTL18_I		1.8	No	Yes
HSTL18_II		1.8	No	Yes
SSTL135		1.35	No	Yes
SSTL15		1.5	No	Yes
SSTL18_I		1.8	No	Yes
SSTL18_II		1.8	No	Yes
LVCMOS10		1.0	No	No
LVCMOS10UD12		1.2	No	No
LVCMOS10UD15		1.5	No	No
LVCMOS10UD18		1.8	No	No
LVCMOS10UD25		2.5	No	No
LVCMOS10UD33		3.3	No	No
LVCMOS12		1.2	Yes	No
LVCMOS15		1.5	Yes	No
LVCMOS15OD10		1.0	Yes	No
LVCMOS15OD12		1.2	Yes	No
LVCMOS15UD18		1.8	Yes	No
LVCMOS15UD25		2.5	Yes	No
LVCMOS15UD33		3.3	Yes	No
LVCMOS18		1.8	Yes	No
LVCMOS18OD10		1.0	Yes	No
LVCMOS18OD12		1.2	Yes	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
LVCMOS18OD15	Single-ended	1.5	Yes	No
LVCMOS18UD25		2.5	Yes	No
LVCMOS18UD33		3.3	Yes	No
LVCMOS25		2.5	Yes	No
LVCMOS25UD33		3.3	Yes	No
LVCMOS33/ LVTTL33		3.3	Yes	No
LVCMOS33OD25		2.5	Yes	No
LPDDR		1.8	Yes	No
PCI33		3.3	Yes	No
VREF1_DRIVER		1.8/1.2/1.35/1.5	No	Yes

GW5AT-75

GW5AT-75has six GPIO Banks (Bank2~7), two SerDes Banks and a Bank for configuration (Bank 10), as shown in Figure 2-8. Bank 10 can also be used as an I/O Bank.

Figure 2-8 I/O Bank Distribution View (GW5AT-75)



Each Bank has independent I/O power supply V_{CCIO}. V_{CCIO} can be set as 3.3V, 2.5V, 1.8V, 1.5V, 1.35V, 1.2V, or 1V. The auxiliary voltage V_{CCX} supports 1.8V.

To support SSTL, HSTL, etc., each bank also provides one independent voltage source (VREF) as the reference voltage. You can choose from the internal reference voltage of the bank (0.6V, 0.675V, 0.75V, 0.9V and (33%,42%,50%,58%)V_{CCIO}) or the external reference voltage using any IO from the bank.

Different banks in the support different on-chip resistor settings, including single-ended resistors and differential resistors. Single-ended resistor settings are used for SSTL/HSTL inputs and outputs. Differential resistor settings are used for LVDS/PPDS/ RSDS inputs. For more details, refer to *UG304, Arora V Programmable IO (GPIO) User Guide* .

GW5AT-75 I/O standards and configuration options supported are as listed in Table 2-3 and Table 2-4.

Table 2-3 Output I/O Standards and Configuration Options

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
LVDS25	Differen-tial(TLVDS)	2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
BLVDS25		2.5/3.3	3.5/2.5/4.5/6	Multi-point high-speed data transmission
RSDS		2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
MINILVDS		2.5/3.3	3.5/2.5/4.5/6	LCD timing driver inter-face and column driver interface
PPLVDS		2.5/3.3	3.5/2.5/4.5/6	LCD row/column driver
LVDS25E	Differential	2.5	8/4/12/16/24	High-speed point-to-point data transmission
BLVDS25E		2.5	8/4/12/16/24	Multi-point high-speed data transmission
MLVDS25E		2.5	8/4/12/16/24	LCD timing driver inter-face and column driver interface
RSDS25E		2.5	8/4/12/16/24	High-speed point-to-point data transmission
LVPECL33E		3.3	8/4/12/16/24	Universal interface
HSUL12D		1.2	8/4/12	LPDDR2
HSUL12D_I		1.2	8/4/12	LPDDR2
HSTL15D_I		1.5	8/4/12/16	Memory interface
HSTL15D_II		1.5	8/4/12/16	Memory interface
HSTL18D_I		1.8	8/4/12/16	Memory interface
HSTL18D_II		1.8	8/4/12/16	Memory interface
SSTL135D		1.35	8/4/12	Memory interface
SSTL15D		1.5	8/4/12/16	Memory interface
SSTL18D_I		1.8	8/4/12/16/24	Memory interface

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
SSTL18D_II	Differential	1.8	8/4/12/16/24	Memory interface
LPDDRD		1.8	8/4/12/16/24	LPDDR and Mobile DDR
LVCMOS10D		1.0	4	Universal interface
LVCMOS12D		1.2	4/8	Universal interface
LVCMOS15D		1.5	4/8/12	Universal interface
LVCMOS18D		1.8	4/8/12/16/24	Universal interface
LVCMOS25D		2.5	4/8/12/16/24	Universal interface
LVCMOS33D		3.3	8/4/12/16/24	Universal interface
HSUL12	Single-ended	1.2	8/4/12	Memory interface
HSTL12_I		1.2	8/4/12	Memory interface
HSTL15_I		1.5	8/4/12/16	Memory interface
HSTL15_ II		1.5	8/4/12/16	Memory interface
HSTL18_I		1.8	8/4/12/16/24	Memory interface
HSTL18_II		1.8	8/4/12/16/24	Memory interface
SSTL135		1.35	8/4/12	Memory interface
SSTL15		1.5	8/4/12/16	Memory interface
SSTL18_I		1.8	8/4/12/16/24	Memory interface
SSTL18_II		1.8	8/4/12/16/24	Memory interface
LVCMOS10		1.0	4	Universal interface
LVCMOS12		1.2	4/8/12	Universal interface
LVCMOS15		1.5	4/8/12/16	Universal interface
LVCMOS18		1.8	4/8/12/16/24	Universal interface
LVCMOS25		2.5	4/8/12/16/24	Universal interface
LVCMOS33/ LVTTL33		3.3	8/4/12/16/24	Universal interface
LPDDR		1.8	8/4/12/16/24	LPDDR and Mobile DDR
PCI33		3.3	8/4/12/16/24	PC and embedded system

Table 2-4 Input I/O Standards and Configuration Options

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
MIPI	Differential	1.2	No	No

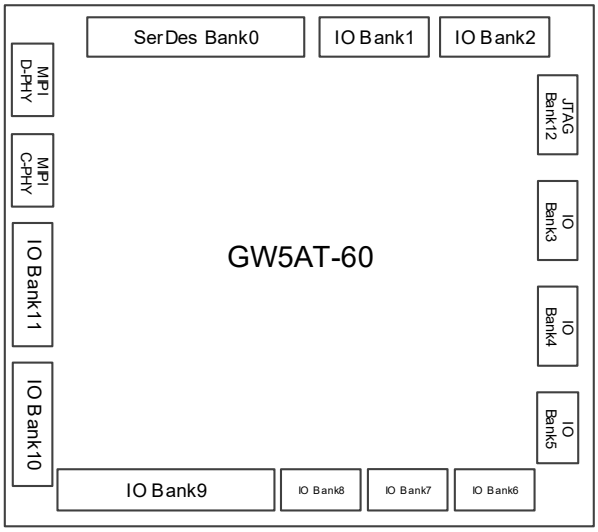
I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
ADC_IN	Differential	2.5/1.0/1.2/1.5/1.8/3.3	No	No
LVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
BLVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
RSDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
MINILVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
PPLVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
HSUL12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL12D_I		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL15D_I		1.5/1.0/1.2/1.8/2.5/3.3	No	No
HSTL15D_II		1.5/1.0/1.2/1.8/2.5/3.3	No	No
HSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No
HSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL135D		1.35/1.0/1.2/1.5/1.8/2.5/3.3	No	No
SSTL15D		1.5/1.0/1.2/1.8/2.5/3.3	No	No
SSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LPDDRD		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LVCMOS10D		1.0/1.2/1.5/1.8/2.5/3.3	No	No
LVCMOS12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
LVCMOS15D		1.5/1.0/1.2/1.8/2.5/3.3	No	No
LVCMOS18D		1.8/1.0/1.2/1.5/2.5/3.3	No	No
HSUL12	Single-ended	1.2	No	Yes
HSTL12_I		1.2	No	Yes
HSTL15_I		1.5	No	Yes
HSTL15_II		1.5	No	Yes
HSTL18_I		1.8	No	Yes
HSTL18_II		1.8	No	Yes
SSTL135		1.35	No	Yes
SSTL15		1.5	No	Yes
SSTL18_I		1.8	No	Yes
SSTL18_II		1.8	No	Yes
LVCMOS10		1.0	No	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
LVCMOS10UD12	Single-ended	1.2	No	No
LVCMOS10UD15		1.5	No	No
LVCMOS10UD18		1.8	No	No
LVCMOS10UD25		2.5	No	No
LVCMOS10UD33		3.3	No	No
LVCMOS12		1.2	Yes	No
LVCMOS15		1.5	Yes	No
LVCMOS15OD10		1.0	Yes	No
LVCMOS15OD12		1.2	Yes	No
LVCMOS15UD18		1.8	Yes	No
LVCMOS15UD25		2.5	Yes	No
LVCMOS15UD33		3.3	Yes	No
LVCMOS18		1.8	Yes	No
LVCMOS18OD10		1.0	Yes	No
LVCMOS18OD12		1.2	Yes	No
LVCMOS18OD15		1.5	Yes	No
LVCMOS18UD25		2.5	Yes	No
LVCMOS18UD33		3.3	Yes	No
LVCMOS25		2.5	Yes	No
LVCMOS25UD33		3.3	Yes	No
LVCMOS33/ LVTTL33		3.3	Yes	No
LVCMOS33OD25		2.5	Yes	No
LPDDR		1.8	Yes	No
PCI33		3.3	Yes	No
VREF1_DRIVER		1.8/1.2/1.35/1.5	No	Yes

GW5AT-60

GW5AT-60 has eleven GPIO Banks. Bank12 is a JTAG Bank with four IOs, as shown in Figure 2-9.

Figure 2-9 I/O Bank Distribution View (GW5AT-60)



Each Bank has independent I/O power supply V_{CCIO}. V_{CCIO} can be set as 3.3V, 2.5V, 1.8V, 1.5V, 1.35V, or 1.2V. The auxiliary voltage V_{CCX} supports 1.8V, 2.5V, and 3.3V.

To support SSTL, HSTL, etc., each bank also provides one independent voltage source (VREF) as the reference voltage. You can choose from the internal reference voltage of the bank (0.6V, 0.75V, 0.9V, 1.25V, 1.5V and (36%,50%,64%)V_{CCIO}) or the external reference voltage using any IO from the bank.

Different banks in the support different on-chip resistor settings, including single-ended resistors and differential resistors. Single-ended resistor settings are used for SSTL/HSTL inputs and outputs. Differential resistor settings are used for LVDS/PPDS/ RSDS inputs. For more details, refer to *UG304, Arora V Programmable IO (GPIO) User Guide* .

GW5AT-60 I/O standards and configuration options supported are as listed in Table 2-5 and Table 2-6.

Table 2-5 Output I/O Standards and Configuration Options

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
MIPI_CPHY	Differential (TLVDS)	2.5/3.3	2	Mobile Industry Processor Interface
MIPI		1.8/2.5/3.3	2	Mobile Industry Processor Interface
MIPI_3MA	Differential (ELVDS)	1.8	3	Mobile Industry Processor Interface
MIPI_4MA		1.8	4	Mobile Industry Processor Interface
LVDS25	Differential (TLVDS)	2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
BLVDS25	Differential (TLVDS)	2.5/3.3	3.5/2.5/4.5/6	Multi-point high-speed data transmission
RSDS		2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
MINILVDS		2.5/3.3	3.5/2.5/4.5/6	LCD timing driver interface and column driver interface
PPLVDS		2.5/3.3	3.5/2.5/4.5/6	LCD row/column driver
LVDS25E	Differential	2.5	8/2/4/6/12/16	High-speed point-to-point data transmission
BLVDS25E		2.5	8/2/4/6/12/16	Multi-point high-speed data transmission
MLVDS25E		2.5	8/2/4/6/12/16	LCD timing driver interface and column driver interface
RSDS25E		2.5	8/2/4/6/12/16	High-speed point-to-point data transmission
LVPECL33E		3.3	8/2/4/6/12/16	Universal interface
HSUL12D		1.2	8/2/4/6	LPDDR2
HSUL12D_I		1.2	8/2/4/6	LPDDR2
HSTL15D_I		1.5	8/4/12	Memory interface
HSTL18D_I		1.8	8/2/4/6/12/16	Memory interface
HSTL18D_II		1.8	8/2/4/6/12/16	Memory interface
SSTL12D_I		1.2	8/2/4/6	Memory interface
SSTL135D_I		1.35	8/2/4/6	Memory interface
SSTL15D_I		1.5	8/2/4/6/12	Memory interface
SSTL18D_I		1.8	8/2/4/6/12/16	Memory interface
SSTL18D_II		1.8	8/2/4/6/12/16	Memory interface
SSTL25D_I		2.5	8/2/4/6/12/16	Memory interface
SSTL25D_ II		2.5	8/2/4/6/12/16	Memory interface
SSTL33D_I		3.3	8/2/4/6/12/16	Memory interface
SSTL33D_II		3.3	8/2/4/6/12/16	Memory interface
LPDDRD		1.8	8/2/4/6/12/16	LPDDR and Mobile DDR
LVCMOS10D		1.0	2/4	Universal interface
LVCMOS12D		1.2	8/2/4/6	Universal interface

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
LVCMOS15D	Differential	1.5	8/2/4/6/12	Universal interface
LVCMOS18D		1.8	8/2/4/6/12/16	Universal interface
LVCMOS25D		2.5	8/2/4/6/12/16	Universal interface
LVCMOS33D		3.3	8/2/4/6/12/16	Universal interface
HSUL12	Single-ended	1.2	8/2/4/6	Memory interface
HSTL12_I		1.2	8/2/4/6	Memory interface
HSTL15_I		1.5	8/2/4/6/12	Memory interface
HSTL18_I		1.8	8/2/4/6/12/16	Memory interface
HSTL18_II		1.8	8/2/4/6/12/16	Memory interface
SSTL12_I		1.2	8/2/4/6	Memory interface
SSTL135_I		1.35	8/2/4/6	Memory interface
SSTL15_I		1.5	8/2/4/6/12	Memory interface
SSTL18_I		1.8	8/2/4/6/12/16	Memory interface
SSTL18_II		1.8	8/2/4/6/12/16	Memory interface
SSTL25_I		2.5	8/2/4/6/12/16	Memory interface
SSTL25_II		2.5	8/2/4/6/12/16	Memory interface
SSTL33_I		3.3	8/2/4/6/12/16	Memory interface
SSTL33_II		3.3	8/2/4/6/12/16	Memory interface
LVCMOS10		1.0	2/4	Universal interface
LVCMOS12		1.2	8/2/4/6	Universal interface
LVCMOS15		1.5	8/2/4/6/12	Universal interface
LVCMOS18		1.8	8/2/4/6/12/16	Universal interface
LVCMOS25		2.5	8/2/4/6/12/16	Universal interface
LVCMOS33/ LVTTL33		3.3	8/2/4/6/12/16	Universal interface
LPDDR		1.8	8/2/4/6/12/16	LPDDR and Mobile DDR
PCI33		3.3	8/2/4/6/12/16	PC and embedded system

Table 2-6 Input I/O Standards and Configuration Options

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
MIPI_CPHY	Differential	1.2/1.5/1.8	No	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
MIPI	Differential	1.2/1.5/1.8	No	No
ADC_IN		2.5/1.0/1.2/1.5/1.8/3.3	No	No
LVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
BLVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
RSDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
MINILVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
PPLVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
HSUL12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL12D_I		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL15D_I		1.5/1.0/1.2/1.8/2.5/3.3	No	No
HSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No
HSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL135D_I		1.35/1.0/1.2/1.5/1.8/2.5/3.3	No	No
SSTL15D_I		1.5/1.0/1.2/1.8/2.5/3.3	No	No
SSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL25D_I		2.5/1.0/1.2/1.5/1.8/3.3	No	No
SSTL25D_ II		2.5/1.0/1.2/1.5/1.8/3.3	No	No
SSTL33D_I		3.3/1.0/1.2/1.5/1.8/2.5	No	No
SSTL33D_ II		3.3/1.0/1.2/1.5/1.8/2.5	No	No
LPDDRD		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LVCMOS10D		1.0/1.2/1.5/1.8/2.5/3.3	No	No
LVCMOS12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
LVCMOS15D		1.5/1.0/1.2/1.8/2.5/3.3	No	No
LVCMOS18D		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LVCMOS25D		2.5/1.0/1.2/1.5/1.8/3.3	No	No
LVCMOS33D		3.3/1.0/1.2/1.5/2.5/1.8	No	No
HSUL12	Single-ended	1.2	Yes	No
HSTL12_I		1.2	Yes	No
HSTL15_I		1.5	Yes	No
HSTL15_II		1.5	Yes	No
HSTL18_I		1.8	Yes	No

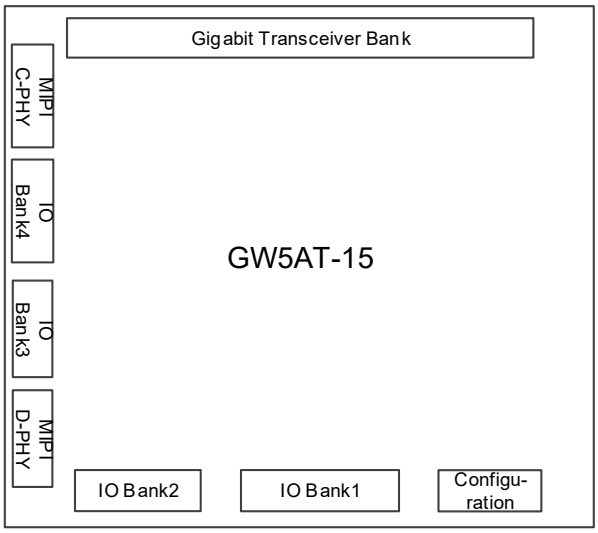
I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
HSTL18_II	Single-ended	1.8	Yes	No
SSTL135_I		1.35	Yes	No
SSTL15_I		1.5	Yes	No
SSTL18_I		1.8	Yes	No
SSTL18_II		1.8	Yes	No
SSTL25_I		2.5	Yes	No
SSTL25_II		2.5	Yes	No
SSTL33_I		3.3	Yes	No
SSTL33_II		3.3	Yes	No
LVCMOS10		1.0	Yes	No
LVCMOS12		1.2	Yes	No
LVCMOS15		1.5	Yes	No
LVCMOS18		1.8	Yes	No
LVCMOS25		2.5	Yes	No
LVCMOS33/ LVTTL33		3.3	Yes	No
LPDDR		1.8	Yes	No
PCI33		3.3	Yes	No
LVCMOS10UD12		1.2	Yes	No
LVCMOS10UD15		1.5	Yes	No
LVCMOS10UD18		1.8	Yes	No
LVCMOS10UD25		2.5	Yes	No
LVCMOS10UD33		3.3	Yes	No
LVCMOS12OD10		1.0	Yes	No
LVCMOS12UD15		1.5	Yes	No
LVCMOS12UD18		1.8	Yes	No
LVCMOS12UD25		2.5	Yes	No
LVCMOS12UD33		3.3	Yes	No
LVCMOS15OD10		1.0	Yes	No
LVCMOS15OD12		1.2	Yes	No
LVCMOS15UD18		1.8	Yes	No
LVCMOS15UD25		2.5	Yes	No
LVCMOS15UD33		3.3	Yes	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
LVCMOS18OD10	Single-ended	1.0	Yes	No
LVCMOS18OD12		1.2	Yes	No
LVCMOS18OD15		1.5	Yes	No
LVCMOS18UD25		2.5	Yes	No
LVCMOS18UD33		3.3	Yes	No
LVCMOS25OD10		2.5	Yes	No
LVCMOS25OD12		3.3	Yes	No
LVCMOS25OD15		1.5	Yes	No
LVCMOS25OD18		1.8	Yes	No
LVCMOS25UD33		3.3	Yes	No
LVCMOS33OD10		1.0	Yes	No
LVCMOS33OD12		1.2	Yes	No
LVCMOS33OD15		1.5	Yes	No
LVCMOS33OD18		1.8	Yes	No
LVCMOS33OD25		2.5	Yes	No
VREF1_DRIVER		1.8/1.2/1.5/2.5/3.3	No	Yes

GW5AT-15

GW5AT-15 includes four GPIO Banks, as shown in Figure 2-10.

Figure 2-10 I/O Bank Distribution View (GW5AT-15)



Each Bank has independent I/O power supply V_{CCIO}. V_{CCIO} can be set as 3.3V, 2.5V, 1.8V, 1.5V, 1.35V, or 1.2V. The auxiliary voltage V_{CCX} supports 1.8V, 2.5V, and 3.3V.

To support SSTL, HSTL, etc., each bank also provides one independent voltage source (VREF) as the reference voltage. You can choose from the internal reference voltage of the bank (0.6V, 0.75V, 0.9V, 1.25V, 1.5V and (36%,50%,64%)V_{CCIO}) or the external reference voltage using any IO from the bank.

Different banks in the support different on-chip resistor settings, including single-ended resistors and differential resistors. Single-ended resistor settings are used for SSTL/HSTL inputs and outputs. Differential resistor settings are used for LVDS/PPDS/ RSDS inputs. For more details, refer to *UG304, Arora V Programmable IO (GPIO) User Guide* .

GW5AT-15 I/O standards and configuration options supported are as listed in Table 2-7 and Table 2-8.

Table 2-7 Output I/O Standards and Configuration Options

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
MIPI_CPHY	Differential (TLVDS)	2.5/3.3	2	Mobile Industry Processor Interface
MIPI		1.8/2.5/3.3	2	Mobile Industry Processor Interface
MIPI_3MA	Differential (ELVDS)	1.8	3	Mobile Industry Processor Interface
MIPI_4MA		1.8	4	Mobile Industry Processor Interface
LVDS25	Differential (TLVDS)	2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
BLVDS25		2.5/3.3	3.5/2.5/4.5/6	Multi-point high-speed data transmission
RSDS		2.5/3.3	3.5/2.5/4.5/6	High-speed point-to-point data transmission
MINILVDS		2.5/3.3	3.5/2.5/4.5/6	LCD timing driver interface and column driver interface
PPLVDS		2.5/3.3	3.5/2.5/4.5/6	LCD row/column driver
LVDS25E	Differential	2.5	8/2/4/6/12/16	High-speed point-to-point data transmission
BLVDS25E		2.5	8/2/4/6/12/16	Multi-point high-speed data transmission
MLVDS25E		2.5	8/2/4/6/12/16	LCD timing driver interface and column driver interface
RSDS25E		2.5	8/2/4/6/12/16	High-speed point-to-point data transmission

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
LVPECL33E	Differential	3.3	8/2/4/6/12/16	Universal interface
HSUL12D		1.2	8/2/4/6	LPDDR2
HSUL12D_I		1.2	8/2/4/6	LPDDR2
HSTL15D_I		1.5	8/4/12	Memory interface
HSTL18D_I		1.8	8/2/4/6/12/16	Memory interface
HSTL18D_II		1.8	8/2/4/6/12/16	Memory interface
SSTL12D_I		1.2	8/2/4/6	Memory interface
SSTL135D_I		1.35	8/2/4/6	Memory interface
SSTL15D_I		1.5	8/2/4/6/12	Memory interface
SSTL18D_I		1.8	8/2/4/6/12/16	Memory interface
SSTL18D_II		1.8	8/2/4/6/12/16	Memory interface
SSTL25D_I		2.5	8/2/4/6/12/16	Memory interface
SSTL25D_ II		2.5	8/2/4/6/12/16	Memory interface
SSTL33D_I		3.3	8/2/4/6/12/16	Memory interface
SSTL33D_II		3.3	8/2/4/6/12/16	Memory interface
LPDDRD		1.8	8/2/4/6/12/16	LPDDR and Mobile DDR
LVCMOS10D		1.0	2/4	Universal interface
LVCMOS12D		1.2	8/2/4/6	Universal interface
LVCMOS15D		1.5	8/2/4/6/12	Universal interface
LVCMOS18D		1.8	8/2/4/6/12/16	Universal interface
LVCMOS25D		2.5	8/2/4/6/12/16	Universal interface
LVCMOS33D		3.3	8/2/4/6/12/16	Universal interface
HSUL12	Single-ended	1.2	8/2/4/6	Memory interface
HSTL12_I		1.2	8/2/4/6	Memory interface
HSTL15_I		1.5	8/2/4/6/12	Memory interface
HSTL18_I		1.8	8/2/4/6/12/16	Memory interface
HSTL18_II		1.8	8/2/4/6/12/16	Memory interface
SSTL12_I		1.2	8/2/4/6	Memory interface
SSTL135_I		1.35	8/2/4/6	Memory interface
SSTL15_I		1.5	8/2/4/6/12	Memory interface
SSTL18_I		1.8	8/2/4/6/12/16	Memory interface
SSTL18_II		1.8	8/2/4/6/12/16	Memory interface

I/O Output Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Output Drive Strength (mA)	Typical Applications
SSTL25_I	Single-ended	2.5	8/2/4/6/12/16	Memory interface
SSTL25_II		2.5	8/2/4/6/12/16	Memory interface
SSTL33_I		3.3	8/2/4/6/12/16	Memory interface
SSTL33_II		3.3	8/2/4/6/12/16	Memory interface
LVCMOS10		1.0	2/4	Universal interface
LVCMOS12		1.2	8/2/4/6	Universal interface
LVCMOS15		1.5	8/2/4/6/12	Universal interface
LVCMOS18		1.8	8/2/4/6/12/16	Universal interface
LVCMOS25		2.5	8/2/4/6/12/16	Universal interface
LVCMOS33/ LVTTL33		3.3	8/2/4/6/12/16	Universal interface
LPDDR		1.8	8/2/4/6/12/16	LPDDR and Mobile DDR
PCI33		3.3	8/2/4/6/12/16	PC and embedded system

Table 2-8 Input I/O Standards and Configuration Options

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
MIPI_CPHY	Differential	1.2/1.5/1.8	No	No
MIPI		1.2/1.5/1.8	No	No
ADC_IN		2.5/1.0/1.2/1.5/1.8/3.3	No	No
LVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
BLVDS25		2.5/1.0/1.2/1.5/1.8/3.3	No	No
RSDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
MINILVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
PPLVDS		2.5/1.0/1.2/1.5/1.8/3.3	No	No
HSUL12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL12D_I		1.2/1.0/1.5/1.8/2.5/3.3	No	No
HSTL15D_I		1.5/1.0/1.2/1.8/2.5/3.3	No	No
HSTL18D_I		1.8/1.0/1.2/1.5/2.5/3.3	No	No
HSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL135D_I		1.35/1.0/1.2/1.5/1.8/2.5/3.3	No	No
SSTL15D_I		1.5/1.0/1.2/1.8/2.5/3.3	No	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
SSTL18D_I	Differential	1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL18D_II		1.8/1.0/1.2/1.5/2.5/3.3	No	No
SSTL25D_I		2.5/1.0/1.2/1.5/1.8/3.3	No	No
SSTL25D_ II		2.5/1.0/1.2/1.5/1.8/3.3	No	No
SSTL33D_I		3.3/1.0/1.2/1.5/1.8/2.5	No	No
SSTL33D_ II		3.3/1.0/1.2/1.5/1.8/2.5	No	No
LPDDRD		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LVCMOS10D		1.0/1.2/1.5/1.8/2.5/3.3	No	No
LVCMOS12D		1.2/1.0/1.5/1.8/2.5/3.3	No	No
LVCMOS15D		1.5/1.0/1.2/1.8/2.5/3.3	No	No
LVCMOS18D		1.8/1.0/1.2/1.5/2.5/3.3	No	No
LVCMOS25D		2.5/1.0/1.2/1.5/1.8/3.3	No	No
LVCMOS33D		3.3/1.0/1.2/1.5/2.5/1.8	No	No
HSUL12	Single-ended	1.2	Yes	No
HSTL12_I		1.2	Yes	No
HSTL15_I		1.5	Yes	No
HSTL15_II		1.5	Yes	No
HSTL18_I		1.8	Yes	No
HSTL18_II		1.8	Yes	No
SSTL135_I		1.35	Yes	No
SSTL15_I		1.5	Yes	No
SSTL18_I		1.8	Yes	No
SSTL18_II		1.8	Yes	No
SSTL25_I		2.5	Yes	No
SSTL25_II		2.5	Yes	No
SSTL33_I		3.3	Yes	No
SSTL33_II		3.3	Yes	No
LVCMOS10		1.0	Yes	No
LVCMOS12		1.2	Yes	No
LVCMOS15		1.5	Yes	No
LVCMOS18		1.8	Yes	No
LVCMOS25		2.5	Yes	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
LVCMOS33/ LVTTL33	Single-ended	3.3	Yes	No
LPDDR		1.8	Yes	No
PCI33		3.3	Yes	No
LVCMOS10UD12		1.2	Yes	No
LVCMOS10UD15		1.5	Yes	No
LVCMOS10UD18		1.8	Yes	No
LVCMOS10UD25		2.5	Yes	No
LVCMOS10UD33		3.3	Yes	No
LVCMOS12OD10		1.0	Yes	No
LVCMOS12UD15		1.5	Yes	No
LVCMOS12UD18		1.8	Yes	No
LVCMOS12UD25		2.5	Yes	No
LVCMOS12UD33		3.3	Yes	No
LVCMOS15OD10		1.0	Yes	No
LVCMOS15OD12		1.2	Yes	No
LVCMOS15UD18		1.8	Yes	No
LVCMOS15UD25		2.5	Yes	No
LVCMOS15UD33		3.3	Yes	No
LVCMOS18OD10		1.0	Yes	No
LVCMOS18OD12		1.2	Yes	No
LVCMOS18OD15		1.5	Yes	No
LVCMOS18UD25		2.5	Yes	No
LVCMOS18UD33		3.3	Yes	No
LVCMOS25OD10		2.5	Yes	No
LVCMOS25OD12		3.3	Yes	No
LVCMOS25OD15		1.5	Yes	No
LVCMOS25OD18		1.8	Yes	No
LVCMOS25UD33		3.3	Yes	No
LVCMOS33OD10		1.0	Yes	No
LVCMOS33OD12		1.2	Yes	No
LVCMOS33OD15		1.5	Yes	No
LVCMOS33OD18		1.8	Yes	No

I/O Input Standard	Single-ended/ Differential	Bank V_{CCIO}(V)	Hysteresis	Need V_{REF}
LVCMOS33OD25	Single-ended	2.5	Yes	No
VREF1_DRIVER		1.8/1.2/1.5/2.5/3.3	No	Yes

2.3.2 I/O Logic

Figure 2-11 shows the I/O logic output of GW5AT Series of FPGA Products

Figure 2-11 I/O Logic Output

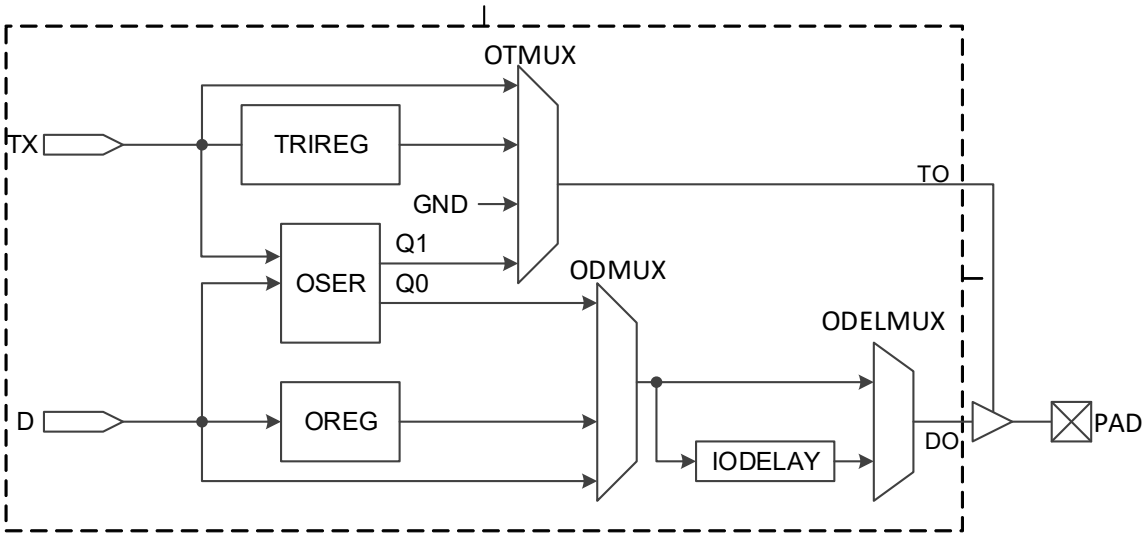
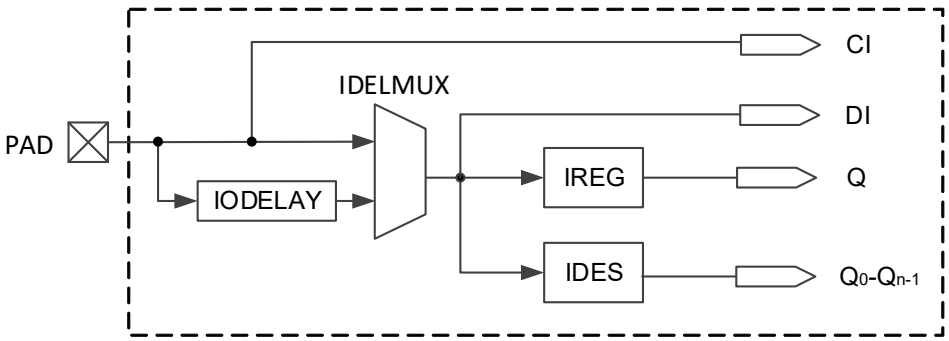


Figure 2-12 shows the I/O logic input of GW5AT Series of FPGA Products.

Figure 2-12 I/O Logic Input



Descriptions of the I/O logic modules of products are presented below.

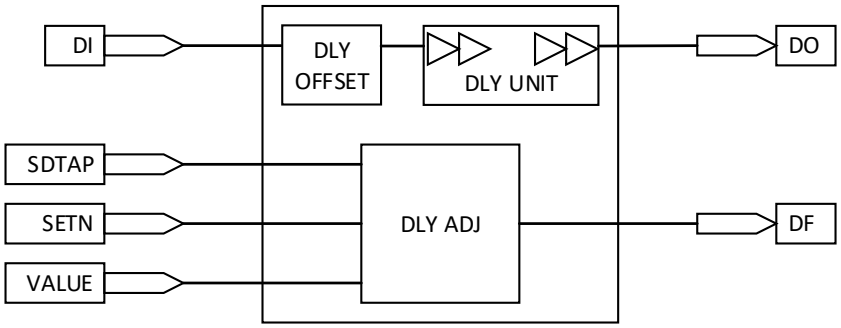
Delay Module

See Figure 2-13 for an overview of the IODELAY. Each I/O contains an IODELAY module, which allows the user to add additional delays to the I/Os to adjust the delay of the input and output signals. The delay time for each step is $T_{dlyunit}$, and the total number of delay steps is DLYSTEP. The total IODELAY delay time is: $T_{totdly} = T_{dlyoffset} + T_{dlyunit} *$ DLYSTEP. The total delay reference time is as shown in Table 2-9.

Table 2-9 Total Delay Reference of IODELAY

	Min.	Typ.	Max.
$T_{dlyoffset}$	200 ps	250 ps	300 ps
$T_{dlyunit}$	10 ps	12.5 ps	15 ps
DLYSTEP	1	-	256

Figure 2-13 IODELAY View



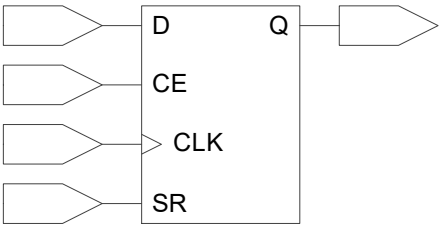
There are three ways to control the delay:

- Static control.
- Dynamic control, which can be combined with logic function circuits to achieve dynamic delay adjustment.
- Adaptive control.

I/O Register

See Figure 2-14 for the I/O Register diagram. Each I/O provides an input register (IREG), an output register(OREG), and a tristate Register(TRIREG).

Figure 2-14 Diagram of I/O registers



Note!

- CE can be either active ow (0: enable)or active high (1: enable).
- CLK can be either rising edge trigger or falling edge trigger.
- SR can be either synchronous/asynchronous SET or RESET or disable.
- The registers can be programmed as registers(DFFs) or latches.

DES and SER

GW5AT Series of FPGA Products support serialization and deserialization of various ratios, as listed in Table 2-10.

Table 2-10 Serialization/Deserialization

Input/output	Ratios Supported
Input Logic	1:2 / 1:4 / 1:7 / 1:8 / 1:10 / 1:14 / 1:16 / 1:32
Output Logic	2:1 / 4:1/ 7:1 / 8:1 / 10:1 / 16:1 / 14:1[1]

Note!

GW5AT-138/GW5AT-75 does not support 14:1.

2.3.3 I/O Logic Modes

The I/O Logic supports multiple modes. In each operation, the I/O (or I/O differential pair) can be configured as output, input, and INOUT or tristate output (output signal with tristate control).

For further details about the I/O logic modes, please refer to *UG304, Arora V Programmable IO (GPIO) User Guide*.

2.4 Block SRAM (BSRAM)

2.4.1 Introduction

GW5AT Series of FPGA Products provide abundant block SRAM resources. These memory resources are distributed throughout the FPGA array in rows. Therefore, they are called block static random access memories (BSRAMs). There are five operation modes: Single Port mode, Dual Port mode, Semi Dual Port mode, Semi Dual Port mode with ECC function, and ROM mode.

An abundance of BSRAM resources provide a guarantee for the user's high-performance design. BSRAM’s features:

- The capacity of a BSRAM is 18 Kbits, can be configured up to 36Kbits
- Clock frequency up to 380MHz
- Supports Single Port mode
- Supports Dual Port mode
- Supports Semi Dual Port Mode
- Supports Semi-Dual Port mode with ECC function, provides ECC detection and error correction function
- Supports ROM Mode
- Data width up to 72bits
- Supports byte-enable

- Dual Port and Semi-dual Port support independent clocks and independent data width
- Read mode supports Register Output and Bypass Output
- Write mode supports Normal and Write-Through
- Input registers support synchronous writes

2.4.2 Configuration Mode

BSRAMs in the products support various data widths. See Table 2-11.

Table 2-11 Memory Size Configuration

Capacity	Single Port Mode	Dual Port Mode	Semi Dual Port Mode	Semi Dual Port Mode with ECC Function	Read Only Mode
16Kbits	16K x 1	16K x 1	16K x 1	–	16K x 1
	8K x 2	8K x 2	8K x 2	–	8K x 2
	4K x 4	4K x 4	4K x 4	–	4K x 4
	2K x 8	2K x 8	2K x 8	–	2K x 8
	1K x 16	1K x 16	1K x 16	–	1K x 16
	512 x 32	–	512 x 32	–	512 x 32
18Kbits	2K x 9	2K x 9	2K x 9	–	2K x 9
	1K x 18	1K x 18	1K x 18	–	1K x 18
	512 x 36	–	512 x 36	–	512 x 36
36Kbits	–	–	–	512 x 72	–

For more information on Single Port mode, Dual Port mode, Semi-Dual Port mode, Semi-Dual Port with ECC Function, and ROM mode, please refer to *UG300，Arora V BSRAM & SSRAM User Guide*.

2.4.3 ECC

The BSRAM has a built-in ECC hardcore module, which is mainly used for data detection and correction during data transfer and storage. The features are as follows:

- ECC error detection and correction only supported in SDP 512 x 64 mode
- Supports 1-bit error correction and 2-bit error alarm in 64-bit SRAM data
- 72-bit ECC module contains 64-bit data bits and 8-bit parity bits;
- Bit 31 and bit 63 support 1-bit and 2-bit error injection

2.5 DSP

GW5AT Series of FPGA Products provide brand new DSP resources. This DSP solution can meet user demands for high performance digital signal processing design,

such as FIR, FFT, etc. The DSP blocks have the advantages of stable timing performance, high resource utilization, and low power consumption.

The features of DSP are as follows.

- Multiplier with three widths: 12X12, 27X18, 27X36
- 26-bit pre-adder
- 48-bit ALU
- Supports Shift function
- Multiple multipliers can achieve multiply of larger data widths by cascading
- Supports accumulation, multiplication and addition of 27X18 multipliers
- Supports the accumulation after summation of two 12X12 multipliers
- Supports the pipeline and bypass functions of registers
- All operands for arithmetic operation are signed numbers

Each DSP consists of three stages:

- PADD
- MULT
- Arithmetic Logic Unit

2.5.1 PADD

Each DSP features one PADD(pre-adder) for implementing pre-addition, pre-subtraction, and shifting.

PADD locates at the first stage with two inputs. Each input end supports pipeline mode and bypass mode.

2.5.2 MULT

Each DSP block has one 27 x 18 multiplier M0 and one 12 x 12 multiplier M1. The multipliers are located after the pre-adders to implement multiplication operations, and both the inputs and outputs support register mode and bypass mode.

Multiplier M0 can be configured as:

- One 27 x 18 multiplier
- One 12 x 12 multiplier
- Two DSPs can form a 27 x 36 multiplier

Multiplier M1 can only be configured as one 12 x 12 multiplier.

When multiplier M0 and multiplier M1 are both configured as a 12 x 12 multiplier and the ALU is enabled, 12 x 12 SUM mode can be achieved.

2.5.3 Arithmetic Logic Unit

Each Macro has one four-input 48-bit ALU, which can further enhance MULT's functions. Register mode and bypass mode are supported both in the inputs and outputs. The ALU supports the addition/subtraction operations of multiplier output, ALU cascade input and ALU output feedback, or static PRE_LOAD value.

2.5.4 Operating Mode

Multiple operation modes of the DSP can be realized by control signals. Operation Modes:

- Multiplier
- Accumulator
- MULTADDALU
- Addition (48+48)

For more information on DSP Blocks, see *UG305, Arora V Digital Signal Processing (DSP) User Guide*.

2.6 Gigabit Transceivers

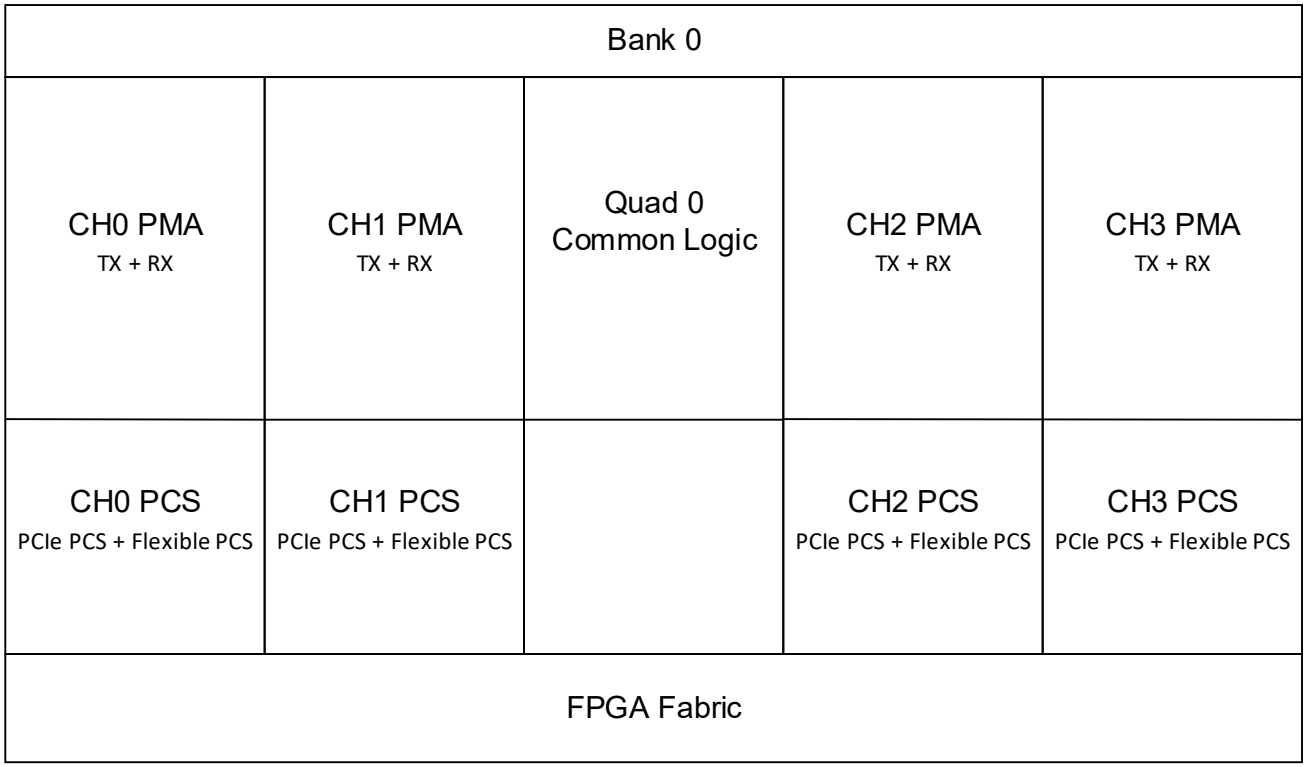
GW5AT Series of FPGA Products support one/two Transceiver Quads. Each Quad supports up to four transceivers, and each transceiver includes one TX and one RX, with the data rate raging from 270Mbps to 12.5Gbps, and supports flexible PMA and PCS.

Figure 2-15 shows the structure view of Transceiver Quad. The protocols supported are as follows:

- PCI Express, V3.0 (2.5 Gbps /5.0 Gbps)
- 10 Gigabit Attachment Unit Interface (XAUI) (3.125Gbps)
- RXAUI (Reduced XAUI) (6.25Gbps)
- CEI-6G-SR (6.375Gbps)
- SATA Rev3.2 (6Gbps/3Gbps/1.5Gbps) (need soft IP support)
- Serial GMII(SGMII) (1.25Gbps)
- CPRI (need soft IP support; soft IP available)
- JESD204B (need soft IP support; soft IP available)
- Rapid-IO (need soft IP support; soft IP available)
- 1000Base-X (need soft IP support; soft IP available)
- 10G-Base-R (need soft IP support; soft IP available)
- SDI-TX/RX (need soft IP support; soft IP available)
- SLVS-EC(RX) (need soft IP support; soft IP available)

- Interlaken

Figure 2-15 Gigabit Transceiver Architecture View



2.6.1 PMA

- Each PMA contains 4 lanes. Each lane supports simultaneous sending and receiving of data, including independent TX and RX, and supports different rates of sending and receiving.
- Each Quad shares two PLLS (one is LC PLL, the other is ring oscillator PLL)
- Transmitter through tracking of spread reference clock.
- Lane driver with programmable transmitter equalization with 1 tap pre-cursor and 1 tap post-cursor to improve signal integrity.
- Voltage mode/current mode lane driver with board AC coupling.
- Programmable continuous time linear equalizer (CTLE) with auto-adaption.
- Receiver CDR track SSC data and tolerance +/- 5000ppm variation.
- Beacon signaling generation and detection for PCI Express.

2.6.2 PCS

- Dedicated hard PCIe PCS
- Flexible PCS to support PCS customization
- 8b/10b encoder/decoder
- GW5AT-15 supports 8b/10b/64b/66b encoder/decoder
- Supports TX channel bonding

- Supports RX channel bonding and CTC
- Utilize IF FIFO to simply user system design
- Supports flexible parallel data widths of 8/10/16/20/32/40/64/80 bits

2.7 PCI Express (PCIe) Controller

GW5AT Series of FPGA Products include one integrated block for PCI Express technology. It allows custom FPGA-to-FPGA communication via the PCI Express protocol, and to attach ASSP Endpoint devices, such as Ethernet Controllers or Fiber Channel HBAs (Host Bus Adapter), to the FPGA.

Features of the PCIe integrated block are as follows:

- Compliant to the PCI Express Base Specification 3.0
- Supports x1, x2, x4 lanes
- GW5AT-138 Supports x1, x2, x4, x8 lanes
- Supports End Point
- Supports Gen1 (2.5 GT/s), Gen2 (5 GT/s), and Gen3 (8 GT/s)
- Up to six BARs (Base Address Register), resizable
- Supports up to 4KB data transfer load
- Supports Autonomous link speed/width change
- Supports advanced configuration options, Advanced Error Reporting (AER), and End-to-End CRC (ECRC) features
- Configurable parameters: channel width, maximum payload size, FPGA logical interface speeds, reference clock frequency, base address register decoding and filtering, etc.

For more information on PCIe Controller, see *IPUG1020E, Arora V PCIe Controller User Guide*.

2.8 MIPI D-PHY

2.8.1 Hardcore MIPI D-PHY RX/TX

GW5AT Series of FPGA Products include the Hardcore MIPI D-PHY RX/TX. The dedicated D-PHY core supports MIPI DSI and CSI-2 mobile video interfaces for cameras and displays. The main features are as follows:

- In line with *MIPI Supported Standard for D-PHY Specification*, version 1.2;
- Unidirectional HS (High-speed) mode at up to 2.5 Gbps per lane and 10 Gbps per quad (4 data lanes). Up to 20 Gbps supported by each chip (8 data lanes).
- Supports two MIPI D-PHY quads, up to 4 data lanes and one clock lane for each quad.
- Bidirectional Low-power (LP) mode with a bit rate of 10Mbps.
- Built-in HS Sync, bit alignment in the lane (Word Alignment) and word alignment between lanes (Lane Alignment).
- MIPI D-PHY RX supports 1:8 mode and 1:16 mode.
- GW5AT-60 and GW5AT-15 MIPI D- PHY TX supports 8:1 mode and 16:1 mode.
- Supports MIPI DSI and MIPI CSI-2 link layers.
- A dedicated MIPI Bank for the hardcore MIPI D-PHY.

For more information on Gowin MIPI D- PHY RX, pleae refer to *UG296，Arora V Hardened MIPI D-PHY User Guide*.

2.8.2 GPIO Supports MIPI D-PHY RX/TX

When implementing soft MIPI D-PHY RX/TX with GPIOs, three IO types are available: TLVDS, ELVDS, and MIPI IO.

All GW5AT Series of FPGA Products support the TLVDS/ELVDS types. To implement MIPI D-PHY with the TLVDS/ELVDS types, you need to emulate MIPI HS and MIPI LP by using LVDS25(E)+LVCMOS12 and need to add external resistors. Some GW5AT Series of FPGA Products support the MIPI-IO type. The MIPI IO has an internal resistor network and supports automatic switching between HS and LP. The support list of the MIPI IO type is shown in Table 2-12.

For information on IO type selection and off-chip termination, please refer to *IPUG948E, MIPI D-PHY RX TX Advance User Guide* > *“4 Functional Description”.*

Table 2-12 GW5AT Series of FPGA Products MIPI IO Type Support List

Device	MIPI RX	MIPI TX
GW5AT-138 GW5AT-75	All Banks	–
GW5AT-60	All Banks (except JTAG Bank)	All Banks (except JTAG Bank)

Device	MIPI RX	MIPI TX
GW5AT-15	All Banks	All Banks

The main features are as follows:

- In line with *MIPI Supported Standard for D-PHY Specification*, version 1.2;
- 138K/75K: High Speed RX and TX interfaces with RX transfer rates up to 1.5Gbps per MIPI lane and TX transfer rates up to 1.6Gbps per MIPI lane.
- The 60K/15K devices have RX/TX transfer rates of up to 2.0 Gbps per lane.
- The 60K/25K devices have RX/TX transfer rates of up to 2.0 Gbps per lane.
- Supports unidirectional High-speed (HS) mode
- Supports bidirectional Low-power operation mode
- Deserializes and serializes high-speed data into byte data packets
- Supports MIPI D-PHY TX 8:1 mode and 16:1 mode
- Supports MIPI D-PHY RX 1:8 mode and 1:16 mode
- Supports IO Types of ELVDS, TLVDS, and MIPI IO
- Control data is transmitted in LP mode at a data rate of 10 Mb/s.

2.9 MIPI C-PHY

2.9.1 Hardcore MIPI C-PHY

GW5AT-60 and GW5AT-15 offer the hard-core MIPI C-PHY RX and TX, featuring highly efficient data transfer rates, and is primarily suited for high-speed serial interfaces between cameras and image processors.

- MIPI Alliance Standard for C-PHY Specification, Version 1.2.
- One MIPI Quad supports up to 3-trios data lanes and RX/TX supports up to 2.5Gsps per lane.
- MIPI C-PHY RX supports high-speed mode and automatic interrupt control..
- MIPI C-PHY TX supports high-speed mode.
- Bidirectional Low mode with data rates up to 10Mbps.
- High speed RX mode supports De-skew function.
- RX supports a linear equalizer with a maximum Delta peak > 8dB.
- Supports ALP mode (optional).

2.9.2 GPIO Supports MIPI C-PHY RX/TX

The GPIOs of GW5AT-60 and GW5AT-15 support MIPI C-PHY MIPI IO types, whicn can be used to implement MIPI C-PHY RX/TX.

The main features are as follows:

- MIPI Alliance Standard for C-PHY Specification, Version 1.2.
- Supports 3-trios data lanes
- Supports MIPI C-PHY RX
- Supports MIPI C-PHY TX

2.10 ADC

2.10.1 ADC

GW5AT-138, GW5AT-75, and GW5AT-15 products integrate one eight-channel 10 bits Delta-sigma ADC. It is an ADC with low power, low-leakage current, and high dynamic performance.

Combined with the programmable logic capability of the FPGA, and the integrated voltage and temperature sensing unit, the ADC can meet the internal temperature and power monitoring and data collection requirements. At the same time, the FPGA provides rich and free configurable GPIO interfaces and ADC analog signal interfaces to connect to the voltage channel of the ADC, which can meet the voltage data collection and monitoring requirements outside the chip.

The main features are as follows:

- Number of ADCs for 15K devices: 1
- Number of ADCs for 75K devices: 2
- Number of ADCs for 138K devices: 2
- Reference voltage source: Built-in
- Bit width accuracy: 10 bits
- Sampling Clock: < 2MHz
- ADC unipolar input voltage: 0~1V
- 60dB SNR
- Temperature sensor accuracy: +/-2℃
- Voltage sensor accuracy: +/-5mV

For more information on ADC, see *UG299E, Arora V ADC User Guide*.

2.10.2 SARADC

GW5AT-60 integrates a SARADC. SARADC is a 13bit ADC for high-speed signal sampling, which is capable of meeting high-precision reference voltage requirements, and is usually used in scenarios requiring high precision. The main features are as follows:

- Reference voltage source: Built-in
- Number of input channel per ADC: Supports up to 122 channels[1]
- Bit width accuracy: 13 bits
- Maximum sampling rate: 10Msps
- Sampling Clock: 10MHz~ 320MHz
- Single-ended input signal range: 0V -1V

- Differential signal range: -1V ~ 1V
- Voltage sensor resolution: +/-0.3mV

Note!

Refer to Pinout manuals for details on the number of input channels supported.

2.11 Clock

The clock resources and wiring are critical for high-performance applications in FPGA. GW5AT Series of FPGA Products provide the global clock network (GCLK) which connects to all the registers directly. In addition to the GCLK, PLL, HCLK, DDR memory interface, and DQS, etc. are also provided.

Figure 2-16 Clock Resources(GW5AT-138)

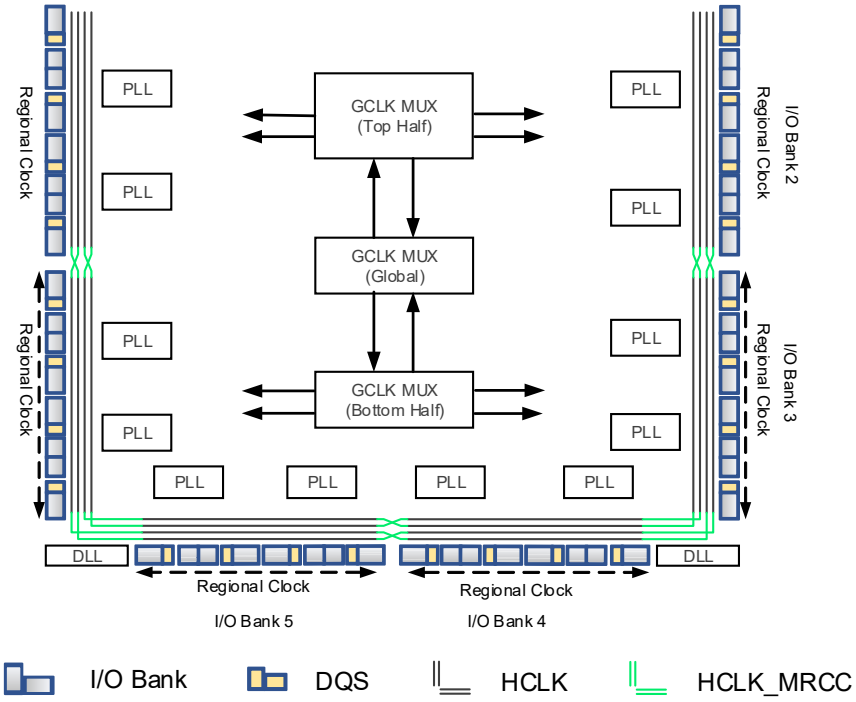


Figure 2-17 Clock Resources(GW5AT-75)

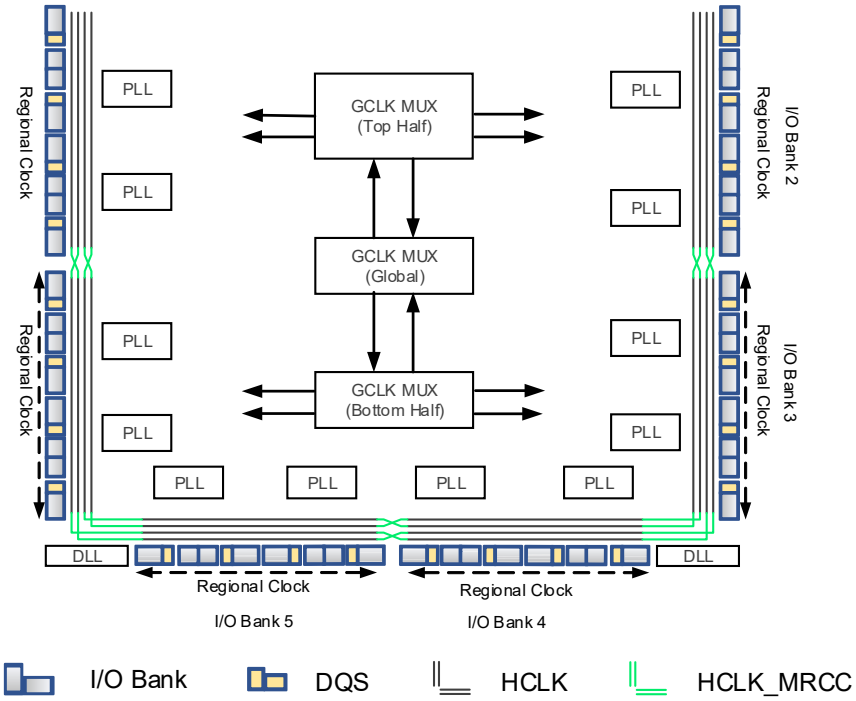


Figure 2-18 Clock Resources(GW5AT-60)

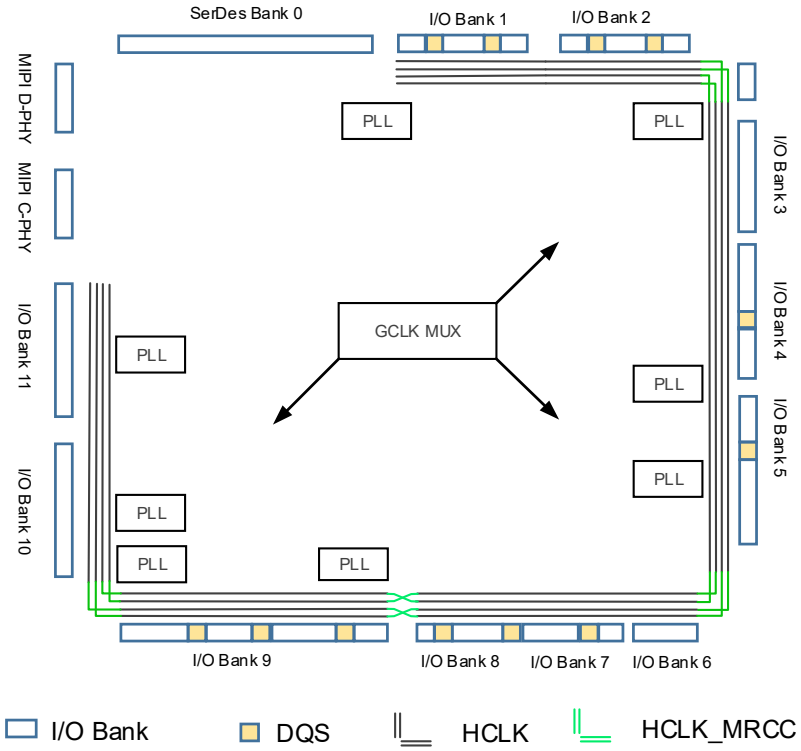
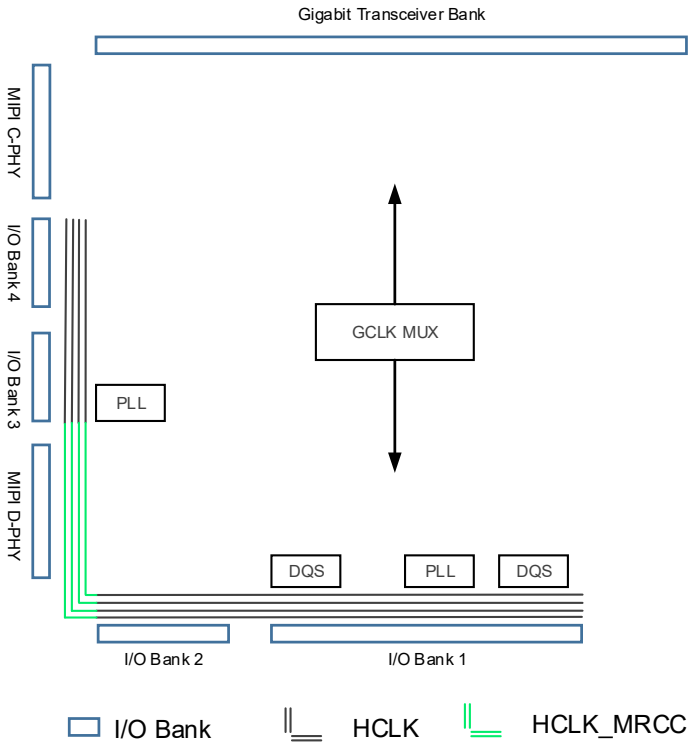


Figure 2-19 Clock Resources(GW5AT-15)



Please refer to *2.11.1 Global Clock* ~ *2.11.4 DDR Memory Interface Clock Management DQS* for a brief introduction. For further detailed information on the GCLK, HCLK, DDR memory interface, and DQS, see *UG306, Arora V Clock User Guide*.

2.11.1 Global Clock

GW5AT Series of FPGA Products provide 16 global clocks. The clock source of GCLK comes from dedicated clock pins, PLL outputs, SERDES clocks, HCLK outputs, and common routing resources. Using a dedicated clock input pin provides better clock performance and enables driving of the global.

2.11.2 High-speed Clock

HCLK is the high-speed clock with low jitter and low skew. It can support high-performance data transfer and is mainly suitable for source synchronous data transfer protocols. One bank supports 4 HCLKs, as shown in Figure 2-20, Figure 2-21, Figure 2-22 , Figure 2-23.

Figure 2-20 HCLK Structure View (GW5AT-138)

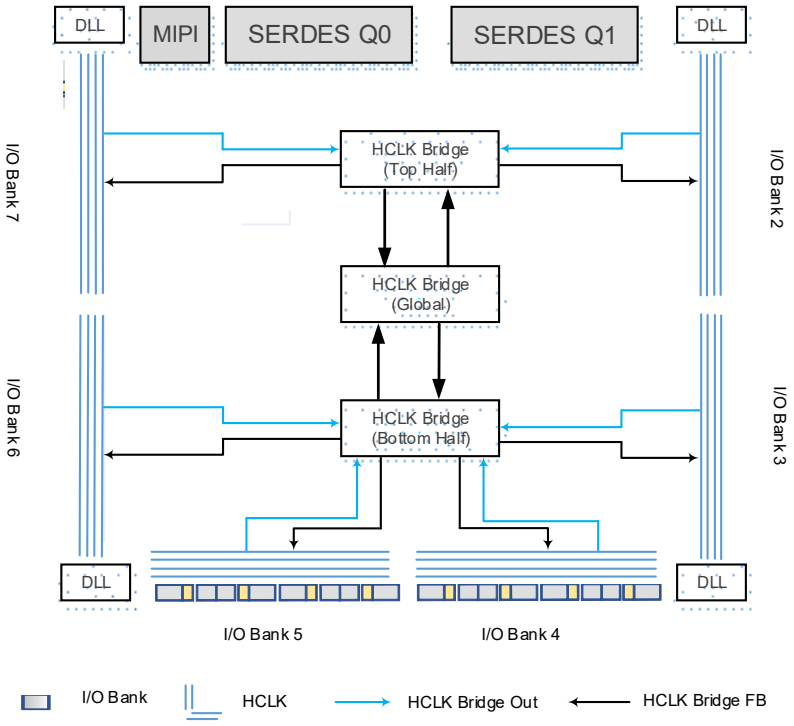


Figure 2-21 HCLK Structure View (GW5AT-75)

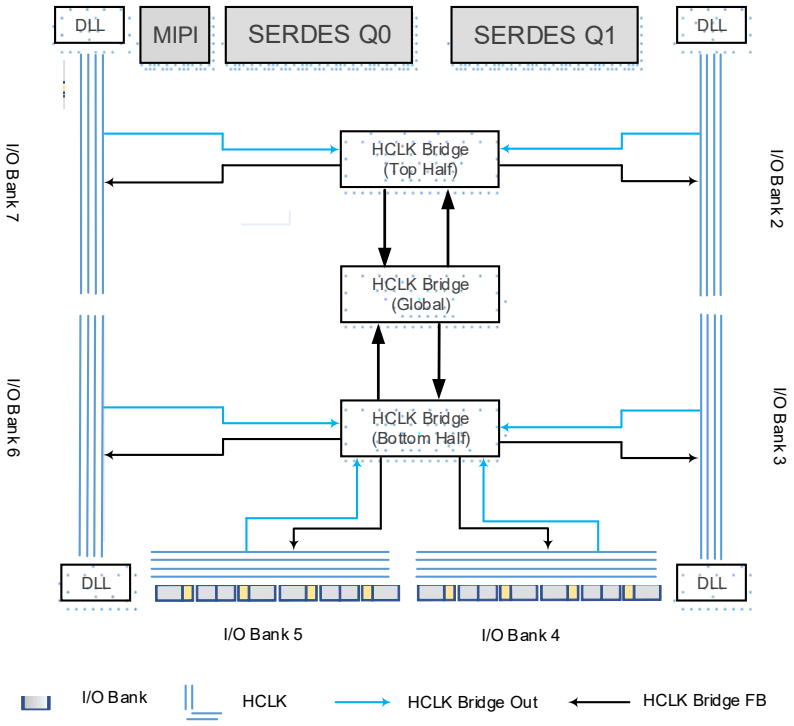


Figure 2-22 HCLK Structure View (GW5AT-60)

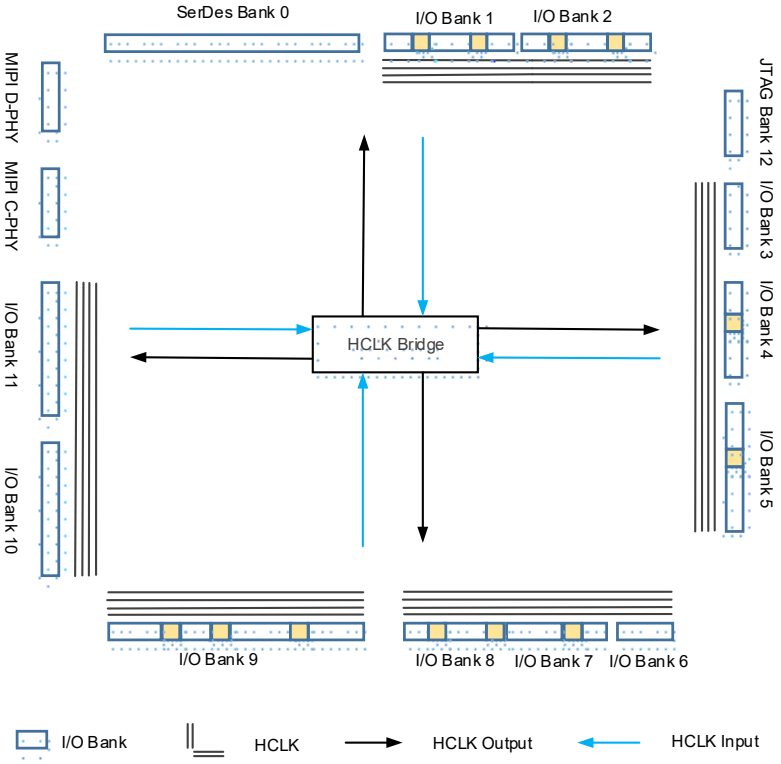
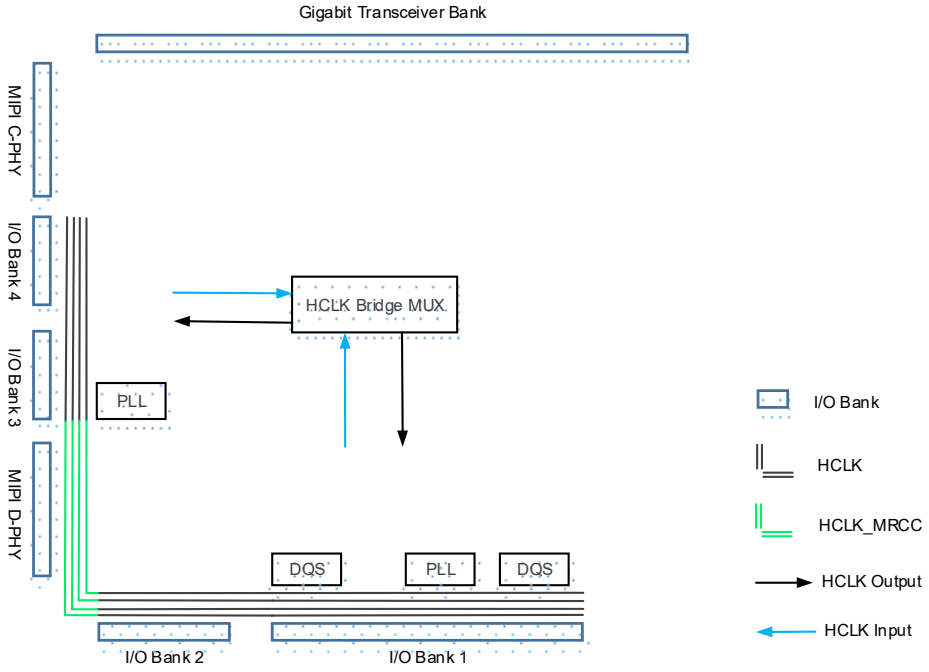


Figure 2-23 HCLK Structure View (GW5AT-15)



HCLK can provide user with the function modules as follows:

- Dynamic high-speed clock enable module. Able to dynamically turn on/off the high-speed clock signal.

- High speed clock frequency division module, generating a divided clock of the input clock. Used in the IO logic mode.
- Dynamic high speed clock selector.
- Dynamic delay adjustment module, producing the clock signal for the dedicated clock pin input.
- HCLK Bridge, able to send HCLK clock signals to any of the Banks. In addition, the HCLK clock signal can span to the clock tree of the adjacent IO Bank after entering from the IO Bank.

Note!

For high speed signals of the same source, it is recommended to put them in the same IO Bank to achieve a minimum skew between signals.

2.11.3 Phase-locked Loop

PLL (Phase-locked Loop) is one kind of a feedback control circuit. The frequency and phase of the internal oscillator signal is controlled by the external input reference clock.

The PLL module can provide synthesizable clock frequencies. Frequency adjustment (multiply and division), phase adjustment, and duty cycle adjustment can be achieved by configuring the parameters.

The PLL features are as follows:

- Supports seven clock outputs
- Integer PLL, the first clock output and feedback clock output support 1/8 fractional output division
- Supports phase shift and duty cycle adjustment
- Frequency Lock detection
- Supports spread spectrum clock generation(IP required)
- VCO frequency range: 800 MHz ~ 1600 MHz
- CLKIN frequency range: 19 MHz ~ 800 MHz.

2.11.4 DDR Memory Interface Clock Management DQS

The DQS module of the products provides the following features to support the clock requirements of the DDR memory interface:

- Receive DQS input, sort out waveform and shift 1/4 phase
- Provide a read / write pointer for input cache
- Provide valid data for internal logic
- Provide DDR output clock signal
- Support DDR3 write voltage control

The DQS module supports multiple operating modes to meet the needs of different I/O interfaces.

2.11.5 Long Wire

As an effective complement to CRUs, GW5AT Series of FPGA Products provide flexible and rich long-wire (LW) resources. LW can be used as a control wire to provide clock enable (CE) for DFF, set/reset signal; it can also be used as logic winding and as a common data signal.

2.12 Global Set/Reset (GSR)

A global set/rest (GSR) network is built in the product. There is a direct connection to core logic. It can be used as asynchronous/synchronous set. The registers in CFU and I/O can be individually configured to use GSR.

2.13 Programming & Configuration

GW5AT Series of FPGA Products support SRAM configuration. Each time the device is powered on, the bitstream needs to be downloaded to configure the device. You can also save the configuration data in an external Flash. After power-up, the devices load configuration data from the external Flash into the SRAM.

Besides JTAG, the devices also support GowinCONFIG configuration modes: SSPI, MSPI, Master CPU, Slave CPU, Master SERIAL, Slave SERIAL, and PCIe. The FPGAs also support background programming, datastream file encryption and security bit setting, SEU detection and error correction, and OTP.

For more detailed information, please refer to:

- *UG704E, Arora V 138K& 75K FPGA Products Programming and Configuration User Guide*
- *UG718E, Arora V 60K FPGA Products Programming and Configuration User Guide*
- *UG720E, Arora V 15K FPGA Products Programming and Configuration User Guide*

2.13.1 Background Upgrade

The products support background upgrade by JTAG/SSPI/QSSPI or using the goConfig I2C IP / goConfig JTAG IP, that is, the device supports programming the embedded Flash or the external Flash without affecting the existing working state, the device can work normally according to the original configuration during the programming process. After the programming is completed, trigger RECONFIG_N with a low level or use “Reboot” to complete the online upgrade. This feature applies to the applications requiring long online time and irregular upgrades.

2.13.2 Bitstream File Encryption & Security Bit Setting

GW5AT Series of FPGA Products support bitstream data encryption with 128-bit AES encryption algorithm. At the same time, GOWINSEMI adds CRC and sets security bits in the bitstream file of FPGA products by default in order to guarantee the safe and accurate transmission of configuration data. During the data configuration process, the input data is verified in real time for errors, and the device cannot be woken up by incorrect data. After the configuration of the bitstream with security bit is complete, data readback cannot be performed.

2.13.3 SEU Handler

The SEU Handler module integrated features Configuration Memory Soft Error Recovery (CMSER). It detects the possible soft errors by continuously monitoring the configuration memory and attempts to correct them within its capabilities. While the FPGA is working, it reads the configuration data frame by frame from the background and performs ECC decoding and CRC checksum comparison to detect errors. If the error can be corrected, the calculated error-corrected data bits are rewritten to the SRAM.

The SEU Handler module functions and features are as follows:

- Based on ECC and CRC detection and correction algorithms
- CRC can report any number of bit errors during configuration of the SRAM.
- ECC supports 2-bit error location report and error correction [1] and 4-bit error alarm in each SRAM Frame. 138K devices support 1-bit error location report and error correction and 2-bit error alarm in each 64-bit SRAM Frame.

Note!

[1] SEU Handler can support faster error correction. Please contact local technical support for details.

- Can be enabled or disabled by user logic or enabled automatically upon program wakeup
- Supports single bit error injection by user logic for the functional verification and evaluation.

2.13.4 OTP

GW5AT Series of FPGA Products provide a 128-bit OTP space and support one-time programming. Bit0~Bit31 is the user space, which can be used to store security and other important information. Bit32~Bit95 is the DNA space, which stores the 64-bit unique identification information of the device.

2.14 On Chip Oscillator

There is an internal oscillator in each of the products. During the configuration process, it can provide a clock for the MSPI mode. The on-chip oscillator also provides a clock

resource for user designs. Up to 64 clock frequencies can be obtained by setting the parameters. The following formula is employed to get the output clock frequency:

f_{out}=210MHz/Param

Note!

“Param” is the configuration parameter. It is 3 or an even number between 2 and 126.

3 AC/DC Characteristic

Note!

You should ensure GOWINSEMI® products are always used within recommended operating conditions and range. Data beyond the working conditions and range are for reference only. GOWINSEMI® does not guarantee that all devices will operate as expected beyond the standard operating conditions and range.

3.1 Operating Conditions

3.1.1 Absolute Max. Ratings

GW5AT-138

Table 3-1 Absolute Max. Ratings(GW5AT-138)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage	-0.5V	1.05V
V_{CCIO}	I/O Bank voltage	-0.5V	3.75V
V_{CCX}	Auxiliary voltage	-0.5V	3.75V
V_{CC_LDO}	Voltage for the internal LDO module that powers the PLL and SRAM	-0.5V	1.98V
$V_{\_EFUSE}$	eFuse writing voltage	-0.5V	2.07V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	-0.5V	1.98V
V_{DDA_Q*}	Analog core power supply	-0.5V	1.05V
V_{DDT_Q*}	TX power supply	-0.5V	1.05V
V_{DDD_Q*}	Digital core power supply	-0.5V	1.05V
MIPI			
V_{DDA_MIPI}	Analog core power supply	-0.5V	1.05V

Name	Description	Min.	Max.
V_{DDX_MIPI}	Analog auxiliary power supply	-0.5V	1.98V
V_{DDD_MIPI}	Digital core power supply	-0.5V	1.05V
ADC			
V_{CC_ADC}	ADC power supply	-0.5V	2.07V
Temperature			
Storage Temperature	Storage Temperature	-65℃	+150℃
Junction Temperature	Junction Temperature	-40℃	+125℃

GW5AT-75

Table 3-2 Absolute Max. Ratings(GW5AT-75)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage	-0.5V	1.05V
V_{CCIO}	I/O Bank voltage	-0.5V	3.75V
V_{CCX}	Auxiliary voltage	-0.5V	3.75V
V_{CC_LDO}	Voltage for the internal LDO module that powers the PLL and SRAM	-0.5V	1.98V
$V_{\_EFUSE}$	eFuse writing voltage	-0.5V	2.07V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	-0.5V	1.98V
V_{DDA_Q*}	Analog core power supply	-0.5V	1.05V
V_{DDT_Q*}	TX power supply	-0.5V	1.05V
V_{DDD_Q*}	Digital core power supply	-0.5V	1.05V
MIPI			
V_{DDA_MIPI}	Analog core power supply	-0.5V	1.05V
V_{DDX_MIPI}	Analog auxiliary power supply	-0.5V	1.98V
V_{DDD_MIPI}	Digital core power supply	-0.5V	1.05V
ADC			
V_{CC_ADC}	ADC power supply	-0.5V	2.07V
Temperature			
Storage Temperature	Storage Temperature	-65℃	+150℃
Junction Temperature	Junction Temperature	-40℃	+125℃

GW5AT-60

Table 3-3 Absolute Max. Ratings(GW5AT-60)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage, LV	-0.5V	1.05V
	Core voltage, EV	-0.5V	3.75V
V_{CCIO}	I/O Bank voltage	-0.5V	3.75V
V_{CCX}	Auxiliary voltage	-0.5V	3.75V
$V_{\_EFUSE}$	Voltage required for eFuse writing	-0.5V	2.07V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	-0.5V	1.98V
$V_{DDA\_ Q*}$	Analog core power supply	-0.5V	1.05V
V_{DDT_Q*}	TX power supply	-0.5V	1.05V
V_{DDD_Q*}	Digital core power supply	-0.5V	1.05V
MIPI			
V_{DDA_MIPI}	Analog core power supply	-0.5V	1.08V
V_{DDX_MIPI}	Analog auxiliary power supply	-0.5V	3.75V
V_{DDD_MIPI}	Digital core power supply	-0.5V	1.08V
V_{DD12_MIPI}	MIPI LP power supply	-0.5V	1.32V
ADC			
V_{CC_ADC}	ADC power supply	-0.5V	2.07V
VREFN	ADC Module reference voltage	-0.5V	0.3V
VREFP	ADC Module reference voltage	-0.5V	2.07V
Temperature			
Storage Temperature	Storage Temperature	-65℃	+150℃
Junction Temperature	Junction Temperature	-40℃	+125℃

GW5AT-15

Table 3-4 Absolute Max. Ratings(GW5AT-15)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage, LV	-0.5V	1.05V
V_{CCIO}	I/O Bank voltage	-0.5V	3.75V

Name	Description	Min.	Max.
V_{CCX}	Auxiliary voltage	-0.5V	3.75V
V_{CC_LDO}	SRAM and PLLRegulator voltage	-0.5V	3.75V
$V_{\_EFUSE}$	Voltage required for eFuse writing	-0.5V	2.07V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	-0.5V	1.98V
V_{DDA_Q*}	Analog core power supply	-0.5V	1.05V
V_{DDT_Q*}	TX power supply	-0.5V	1.05V
MIPI			
V_{DDA_MIPI}	Analog core power supply	-0.5V	1.08V
V_{DDX_MIPI}	Analog auxiliary power supply	-0.5V	3.75V
V_{DDD_MIPI}	Digital core power supply	-0.5V	1.08V
V_{DD12_MIPI}	MIPI LP power supply	-0.5V	1.32V
ADC			
V_{CC_ADC}	ADC power supply	-0.5V	2.07V
PSRAM			
V_{DD_PSRAM}	PSRAM power supply	-0.5V	1.98V
V_{DDQ_PSRAM}	PSRAM data bus power supply	-0.5V	1.98V
FLASH			
V_{CC_FLASH}	FLASH power supply	-0.5V	1.98V
Temperature			
Storage Temperature	Storage Temperature	-65℃	+150℃
Junction Temperature	Junction Temperature	-40℃	+125℃

3.1.2 Recommended Operating Conditions

GW5AT-138

Table 3-5 Recommended Operating Conditions(GW5AT-138)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage	0.87V	1.03V
V_{CCIO}	I/O Bank voltage	1V	3.465V
V_{CCX}	Auxiliary voltage	1.71V	1.89V
V_{CC_LDO} [1]	Voltage for the internal LDO module that powers the PLL and SRAM	1.14V	1.89V

Name	Description	Min.	Max.
$V_{\_EFUSE}$ [2]	eFuse writing voltage	1.62V	1.98V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	1.71V	1.89V
V_{DDA_Q*}	Analog core power supply	0.87V	1.03V
V_{DDT_Q*}	TX power supply	0.87V	1.03V
V_{DDD_Q*}	Digital core power supply	0.87V	1.03V
MIPI			
V_{DDA_MIPI}	Analog core power supply	0.87V	1.03V
V_{DDX_MIPI}	Analog auxiliary voltage power supply	1.71V	1.89V
V_{DDD_MIPI}	Digital core power supply	0.87V	1.03V
ADC			
V_{CC_ADC}	Analog core power supply	1.62V	1.98V
Temperature			
T_{JCOM}	Junction temperature Commercial operation	0℃	+85℃
T_{JIND}	Junction temperature Industrial operation	-40℃	+100℃

Note!

- [1] The greater the V_{CC_LDO} voltage, the higher the power consumption.
- [2] When eFuse is not required, this power supply can be either connected to GND or floating.
- If multiple power supplies are shorted on some packages or PCBs, it is necessary to take the intersection of the ranges of all shorted power supplies to satisfy the needs of multiple power supplies at the same time.

GW5AT-75

Table 3-6 Recommended Operating Conditions(GW5AT-75)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage	0.87V	1.03V
V_{CCIO}	I/O Bank voltage	1V	3.465V
V_{CCX}	Auxiliary voltage	1.71V	1.89V
V_{CC_LDO} [1]	Voltage for the internal LDO module that powers the PLL and SRAM	1.14V	1.89V
$V_{\_EFUSE}$ [2]	eFuse writing voltage	1.62V	1.98V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	1.71V	1.89V

Name	Description	Min.	Max.
V_{DDA_Q*}	Analog core power supply	0.87V	1.03V
V_{DDT_Q*}	TX power supply	0.87V	1.03V
V_{DDD_Q*}	Digital core power supply	0.87V	1.03V
MIPI			
V_{DDA_MIPI}	Analog core power supply	0.87V	1.03V
V_{DDX_MIPI}	Analog auxiliary voltage power supply	1.71V	1.89V
V_{DDD_MIPI}	Digital core power supply	0.87V	1.03V
ADC			
V_{CC_ADC}	Analog core power supply	1.62V	1.98V
Temperature			
T_{JCOM}	Junction temperature Commercial operation	0℃	+85℃
T_{JIND}	Junction temperature Industrial operation	-40℃	+100℃

Note!

- [1] The greater the V_{CC_LDO} voltage, the higher the power consumption.
- [2] When eFuse is not required, this power supply can be either connected to GND or floating.
- If multiple power supplies are shorted on some packages or PCBs, it is necessary to take the intersection of the ranges of all shorted power supplies to satisfy the needs of multiple power supplies at the same time.

GW5AT-60

Table 3-7 Recommended Operating Conditions(GW5AT-60)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage, LV	0.87V	1.03V
	Core voltage, EV	1.14V	1.8V
V_{CCIO}	I/O Bank voltage	1V	3.465V
V_{CCX} [1]	Auxiliary voltage	1.71V	3.465V
$V_{\_EFUSE}$ [2]	Voltage required for eFuse writing	1.62V	1.98V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	1.71V	1.89V
V_{DDA_Q*}	Analog core power supply	0.87V	1.03V
V_{DDT_Q*}	TX power supply	0.87V	1.03V
V_{DDD_Q*}	Digital core power supply	0.87V	1.03V
MIPI			

Name	Description	Min.	Max.
V_{DDA_MIPI}	Analog core power supply	0.87V	1.08V
V_{DDX_MIPI}	Analog auxiliary power supply	1.71V	3.465V
V_{DDD_MIPI}	Digital core power supply	0.87V	1.08V
V_{DD12_MIPI}	MIPI LP power supply	1.14V	1.32V
ADC			
V_{CC_ADC}	ADC power supply	1.62V	1.98V
VREFN	ADC Module reference voltage	0V	0V
VREFP	ADC Module reference voltage	0V	1.25V
Temperature			
T_{JCOM}	Junction temperature Commercial operation	0℃	+85℃
T_{JIND}	Junction temperature Industrial operation	-40℃	+100℃

Note!

- [1] When internal differential termination resistors are required, Vccx must be greater than or equal to 3V; the IO input-output Fmax is limited when Vccx=1.8V, and Vccx needs to be greater than or equal to 2.5V for input-output applications with Fmax greater than 600Mbps.
- [2] When eFuse is not required, this power supply can be either connected to GND or floating.
- If multiple power supplies are shorted on some packages or PCBs, it is necessary to take the intersection of the ranges of all shorted power supplies to satisfy the needs of multiple power supplies at the same time.

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Table 3-8 Recommended Operating Conditions(GW5AT-15)

Name	Description	Min.	Max.
FPGA Logic			
V_{CC}	Core voltage, LV	0.87V	1.03V
V_{CCIO}	I/O Bank voltage	1.14V	3.465V
V_{CCX} [1]	Auxiliary voltage	1.71V	3.465V
V_{CC_LDO}	SRAM and PLLRegulator voltage	1.14V	2.75V
$V_{\_EFUSE}$ [2]	Voltage required for eFuse writing	1.62V	1.98V
Gigabit Transceiver			
V_{DDHA_Q*}	Analog high power supply	1.71V	1.89V
V_{DDA_Q*}	Analog core power supply	0.87V	1.03V
V_{DDT_Q*}	TX power supply	0.87V	1.03V
MIPI			
V_{DDA_MIPI}	Analog core power supply	0.855V	1.08V

Name	Description	Min.	Max.
V_{DDX_MIPI}	Analog auxiliary power supply	1.71V	3.465V
V_{DDD_MIPI}	Digital core power supply	0.87V	1.08V
V_{DD12_MIPI}	MIPI LP power supply	1.14V	1.32V
ADC			
V_{CC_ADC}	ADC power supply	1.62V	1.98V
PSRAM			
V_{DD_PSRAM}	PSRAM power supply	1.71V	1.89V
V_{DDQ_PSRAM}	PSRAM data bus power supply	1.71V	1.89V
FLASH			
V_{CC_FLASH}	FLASH power supply	1.71V	1.89V
Temperature			
T_{JCOM}	Junction temperature Commercial operation	0℃	+85℃
T_{JIND}	Junction temperature Industrial operation	-40℃	+100℃

Note!

- [1] When internal differential termination resistors are required, Vccx must be greater than or equal to 3V; the IO input-output Fmax is limited when Vccx=1.8V, and Vccx needs to be greater than or equal to 2.5V for input-output applications with Fmax greater than 600Mbps.
- [2] When eFuse is not required, this power supply can be either connected to GND or floating.
- If multiple power supplies are shorted on some packages or PCBs, it is necessary to take the intersection of the ranges of all shorted power supplies to satisfy the needs of multiple power supplies at the same time.

3.1.3 Power Supply Ramp Rates

Table 3-9 Power Supply Ramp Rates

Name	Min.	Typ.	Max.
V_{CC} Ramp Rate	0.1mV/μs	TBD	15mV/μs
V_{CC_LDO} Ramp Rate	0.09mV/μs	TBD	15mV/μs
V_{CCX} Ramp Rate	0.005mV/μs	TBD	15mV/μs
V_{CCIO} Ramp Rate	0.06mV/μs	TBD	15mV/μs

3.1.4 Hot Socket Specifications

Table 3-10 Hot Socket Specifications

Name	Description	Condition	I/O	Max.
I_{HS}	Input or I/O leakage current	V_{IN}=V_{IL} (MAX)	I/O	150uA

Name	Description	Condition	I/O	Max.
I_{HS}	Input or I/O leakage current	$V_{IN}=V_{IL}$ (MAX)	TDI, TDO, TMS,TCK	120uA

3.1.5 POR Specifications

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Table 3-11 POR Voltage (GW5AT-138)

Name	Description	Name	Typ.
POR Voltage	Power on reset voltage	V_{CC}	0.72V
		V_{CCX}	1.5V
		V_{CCIO} (Bank10)	1.04V
		V_{CC_REG}	1.03V

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Table 3-12 POR Voltage (GW5AT-75)

Name	Description	Name	Typ.
POR Voltage	Power on reset voltage	V_{CC}	0.72V
		V_{CCX}	1.5V
		V_{CCIO} (Bank10)	1.04V
		V_{CC_REG}	1.03V

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Table 3-13 POR Voltage (GW5AT-60)

Name	Description	Name	Typ.
POR Voltage	Power on reset voltage	V_{CC}	0.69V
		V_{CCX}	1.5V
		V_{CCIO} (Bank3/5/12)	1.05V

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Table 3-14 POR Voltage (GW5AT-15)

Name	Description	Name	Typ.
POR Voltage	Power on reset voltage	V_{CC}	0.71V
		V_{CCX}	1.48V
		V_{CCIO} (Bank10)	1.05V

3.2 ESD performance

Table 3-15 ESD - HBM

Device	HBM
GW5AT-138	HBM ≥ 2000V (GPIO) HBM ≥ 1000V (Gigabit Transceiver, MIPI D-PHY)
GW5AT-75	HBM≥ 2000V HBM ≥ 1000V (Gigabit Transceiver, MIPI D-PHY)
GW5AT-60	HBM ≥ 2000V (GPIO) HBM ≥ 1000V (Gigabit Transceiver, MIPI C-PHY, MIPI D-PHY)
GW5AT-15	HBM ≥ 1000V

Table 3-16 ESD– CDM

Device	CDM
GW5AT-138	CDM≥ 250V
GW5AT-75	CDM≥ 250V
GW5AT-60	CDM≥ 500V
GW5AT-15	CDM≥ 500V

3.3 DC Characteristics

3.3.1 DC Electrical Characteristics-Recommended Operating Conditions

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Table 3-17 DC Electrical Characteristics-Recommended Operating Conditions(GW5AT-138)

Name	Description	Condition	Min.	Typ.	Max.
I_{IL},I_{IH}	Input or I/O leakage	$V_{CCIO}<V_{IN}<V_{IH}$(MAX)	-	-	210uA
		$0V<V_{IN}<V_{CCIO}$	-	-	10uA
I_{PU}	I/O Active Pull-up Current	$0<V_{IN}<0.7V_{CCIO}$, Pull Strength=Strong	-	-	-400uA
		$0<VIN<0.7V_{CCIO}$, Pull Strength=Medium	-	-	-150uA
		$0<VIN<0.7V_{CCIO}$, Pull Strength=Weak	-	-	-50uA
I_{PD}	I/O Active Pull-down Current	V_{IL}(MAX)$<V_{IN}<V_{CCIO}$, Pull Strength=Strong	-	-	400uA
		V_{IL}(MAX)$<V_{IN}<V_{CCIO}$, Pull Strength=Medium	-	-	150uA
		V_{IL}(MAX)$<V_{IN}<V_{CCIO}$, Pull Strength=Weak	-	-	50uA
C1	I/O Capacitance	-	-	5pF	8pF
V_{HYST}	Hysteresis for Schmitt Trigger inputs	V_{CCIO}=3.3V, Hysteresis=ON	-	400mV	
		V_{CCIO}=2.5V, Hysteresis=ON	-	200mV	
		V_{CCIO}=1.8V, Hysteresis=ON	-	100mV	
		V_{CCIO}=1.5V, Hysteresis=ON	-	70mV	
		V_{CCIO}=1.2V, Hysteresis=ON		40mV	

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Table 3-18 DC Electrical Characteristics-Recommended Operating Conditions(GW5AT-75)

Name	Description	Condition	Min.	Typ.	Max.
I_{IL},I_{IH}	Input or I/O leakage	$V_{CCIO}<V_{IN}<V_{IH}$(MAX)	-	-	210uA
		$0V<V_{IN}<V_{CCIO}$	-	-	10uA

Name	Description	Condition	Min.	Typ.	Max.
I_{PU}	I/O Active Pull-up Current	0<V_{IN}<0.7V_{CCIO}, Pull Strength=Strong	-	-	-400uA
		0<VIN<0.7V_{CCIO}, Pull Strength=Medium	-	-	-150uA
		0<VIN<0.7V_{CCIO}, Pull Strength=Weak	-	-	-50uA
I_{PD}	I/O Active Pull-down Current	V_{IL}(MAX)<V_{IN}<V_{CCIO}, Pull Strength=Strong	-	-	400uA
		V_{IL}(MAX)<V_{IN}<V_{CCIO}, Pull Strength=Medium	-	-	150uA
		V_{IL}(MAX)<V_{IN}<V_{CCIO}, Pull Strength=Weak	-	-	50uA
C1	I/O Capacitance	-	-	5pF	8pF
V_{HYST}	Hysteresis for Schmitt Trigger inputs	V_{CCIO}=3.3V, Hysteresis=ON	-	400mV	
		V_{CCIO}=2.5V, Hysteresis=ON	-	200mV	
		V_{CCIO}=1.8V, Hysteresis=ON	-	100mV	
		V_{CCIO}=1.5V, Hysteresis=ON	-	70mV	
		V_{CCIO}=1.2V, Hysteresis=ON		40mV	

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Table 3-19 DC Electrical Characteristics - Recommended Operating Conditions (GW5AT-60)

Name	Description	Condition	Min.	Typ.	Max.
I_{IL},I_{IH}	Input or I/O leakage	V_{CCO}<V_{IN}<V_{IH}(MAX)	-		210uA
		0V<V_{IN}<V_{CCO}	-		10uA
I_{PU}	I/O Active Pull-up Current	0<V_{IN}<0.7V_{CCO}, Pull Strength=Strong	-		-400uA
		0<VIN<0.7VCCO, Pull Strength=Medium			-150uA
		0<VIN<0.7VCCO, Pull Strength=Weak			-50uA
I_{PD}	I/O Active Pull-down Current	V_{IL}(MAX)<V_{IN}<V_{CCO}, Pull Strength=Strong	-		400uA

Name	Description	Condition	Min.	Typ.	Max.
I_{PD}	I/O Active Pull-down Current	$V_{IL}(MAX)<V_{IN}<V_{CCO}$, Pull Strength=Medium			150uA
		$V_{IL}(MAX)<V_{IN}<V_{CCO}$, Pull Strength=Weak			50uA
C1	I/O Capacitance			5pF	8pF
V_{HYST}	Hysteresis for Schmitt Trigger inputs	V_{CCO}=3.3V, Hysteresis=ON	-	400mV	
		V_{CCO}=2.5V, Hysteresis=ON	-	250mV	
		V_{CCO}=1.8V, Hysteresis=ON	-	150mV	
		V_{CCO}=1.5V, Hysteresis=ON	-	130mV	
		V_{CCO}=1.2V, Hysteresis=ON		40mV	

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Table 3-20 DC Electrical Characteristics - Recommended Operating Conditions(GW5AT-15)

Name	Description	Condition	Min.	Typ.	Max.
I_{IL},I_{IH}	Input or I/O leakage	$V_{CCO}<V_{IN}<V_{IH}(MAX)$	-		210uA
		$0V<V_{IN}<V_{CCO}$	-		10uA
I_{PU}	I/O Active Pull-up Current	$0<V_{IN}<0.7V_{CCO}$, Pull Strength=Strong	-		-400uA
		$0<VIN<0.7V_{CCO}$, Pull Strength=Medium			-150uA
		$0<VIN<0.7V_{CCO}$, Pull Strength=Weak			-50uA
I_{PD}	I/O Active Pull-down Current	$V_{IL}(MAX)<V_{IN}<V_{CCO}$, Pull Strength=Strong	-		400uA
		$V_{IL}(MAX)<V_{IN}<V_{CCO}$, Pull Strength=Medium			150uA
		$V_{IL}(MAX)<V_{IN}<V_{CCO}$, Pull Strength=Weak			50uA
C1	I/O Capacitance			5pF	8pF
V_{HYST}	Hysteresis for Schmitt Trigger inputs	V_{CCO}=3.3V, Hysteresis=ON	-	400mV	
		V_{CCO}=2.5V, Hysteresis=ON	-	250mV	
		V_{CCO}=1.8V, Hysteresis=ON	-	150mV	

Name	Description	Condition	Min.	Typ.	Max.
V_{HYST}	Hysteresis for Schmitt Trigger inputs	V_{CCO}=1.5V, Hysteresis=ON	-	130mV	
		V_{CCO}=1.2V, Hysteresis=ON		40mV	

3.3.2 Static Current

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Table 3-21 Static Current (GW5AT-138)

Name	Description	LV/UV	Typ.[1]
I_{CC}	Core current	LV	100 mA
I_{CCX}	V_{CCX} current	LV	9 mA
I_{CCIO}	I/O Bank current (V_{CCIO}=2.5V)	LV	5 mA
I_{CC_LDO}	Static current (Built-in Regulator)	LV	6 mA

Note!

[1] The test condition for the typical value is 25℃.

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Table 3-22 Static Current (GW5AT-75)

Name	Description	LV/UV	Typ.[1]
I_{CC}	Core current	LV	100 mA
I_{CCX}	V_{CCX} current	LV	9 mA
I_{CCIO}	I/O Bank current (V_{CCIO}=2.5V)	LV	5 mA
I_{CC_LDO}	Static current (Built-in Regulator)	LV	6 mA

Note!

[1] The test condition for the typical value is 25℃.

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Table 3-23 Static Current (GW5AT-60)

Name	Description	LV/UV	Typ.[1]
I_{CC}	Core current	LV	80 mA
I_{CCX}	V_{CCX} current	LV	5 mA
I_{CCIO}	I/O Bank current (V_{CCIO}=2.5V)	LV	1 mA

Note!

[1] The test condition for the typical value is 25℃.

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Table 3-24 Static Current(GW5AT-15)

Name	Description	LV/UV	Typ.[1]
I_{CC}	Core Current	LV	40 mA
I_{CCX}	V_{CCX} current(V_{CCX}=1.8V)	LV	4.8 mA
I_{CCIO}	I/O Bank voltage (V_{CCIO}=1.8V)	LV	5 mA

Note!

[1] The test condition for the typical value is 25℃.

3.3.3 Recommended I/O Operating Conditions

Table 3-25 Recommended I/O Operating Conditions

Name	Output V_{CCIO} (V)			Input V_{REF} (V)		
	Min.	Typ.	Max.	Min.	Typ.	Max.
LVTTL33	3.135	3.3	3.465	-	-	-
LVCMOS33	3.135	3.3	3.465	-	-	-
LVCMOS25	2.375	2.5	2.625	-	-	-
LVCMOS18	1.71	1.8	1.89	-	-	-
LVCMOS15	1.425	1.5	1.575	-	-	-
LVCMOS12	1.14	1.2	1.26	-	-	-
SSTL15	1.425	1.5	1.575	0.68	0.75	0.9
SSTL18_I	1.71	1.8	1.89	0.833	0.9	0.969
SSTL18_II	1.71	1.8	1.89	0.833	0.9	0.969
SSTL25_I	2.375	2.5	2.645	1.15	1.25	1.35
SSTL25_II	2.375	2.5	2.645	1.15	1.25	1.35
SSTL33_I	3.135	3.3	3.465	1.3	1.5	1.7
SSTL33_II	3.135	3.3	3.465	1.3	1.5	1.7
HSTL18_I	1.71	1.8	1.89	0.816	0.9	1.08
HSTL18_II	1.71	1.8	1.89	0.816	0.9	1.08
HSTL15	1.425	1.5	1.575	0.68	0.75	0.9
PCI33	3.135	3.3	3.465	-	-	-
LVPECL33E	3.135	3.3	3.465	-	-	-
MLVDS25E	2.375	2.5	2.625	-	-	-
BLVDS25E	2.375	2.5	2.625	-	-	-
RSDS25E	2.375	2.5	2.625	-	-	-

Name	Output V_{CCIO} (V)			Input V_{REF} (V)		
	Min.	Typ.	Max.	Min.	Typ.	Max.
LVDS25E[1]	2.375	2.5	2.625	-	-	-
SSTL15D	1.425	1.5	1.575	-	-	-
SSTL18D_I	1.71	1.8	1.89	-	-	-
SSTL18D_II	1.71	1.8	1.89	-	-	-
SSTL25D_I	2.375	2.5	2.625	-	-	-
SSTL25D_II	2.375	2.5	2.625	-	-	-
SSTL33D_I	3.135	3.3	3.465	-	-	-
SSTL33D_II	3.135	3.3	3.465	-	-	-
HSTL15D	1.425	1.575	1.89	-	-	-
HSTL18D_I	1.71	1.8	1.89	-	-	-
HSTL18D_II	1.71	1.8	1.89	-	-	-

Note!

V_{CCIO} of Banks with True LVDS is recommended to be set to 2.5 V.

3.3.4 Single ended I/O DC Characteristic

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Table 3-26 Single-ended I/O DC Characteristics (GW5AT-138)

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS33 LVTTL33	-0.3V	0.8V	2.0V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
							24	-24
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS25	-0.3V	0.7V	1.7V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
							24	-24
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS18	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS18	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	8	-8
							12	-12
							16	-16
							24	-24
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS15	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS12	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS10	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	1.1V	0.4V	V_{CCIO}-0.4V	1.5	-0.5
PCI33	-0.3V	0.3 x V_{CCIO}	0.5 x V_{CCIO}	V_{CCIO}+0.3	0.1x V_{CCIO}	0.9 x V_{CCIO}	1.5	-0.5
SSTL18_II	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	13.4	-13.4
SSTL18_I	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	8	-8
SSTL15	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	13	-13
SSTL135	-0.3V	V_{REF}-0.09V	V_{REF}+0.09V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	13	-13
HSTL18_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	8	-8
HSTL18_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	16	-16
HSTL15_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	8	-8
HSTL15_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	16	-16
HSUL12	-0.3V	V_{REF}-0.13V	V_{REF}+ 0.13V	V_{CCIO}+0.3	0.40	V_{CCIO}-0.40V	0.1	-0.1

Note!

[1] The total DC current limit(sourced and sinked) of all IOs in the same bank: the total DC current of all IOs in the same bank shall not be greater than n*8mA, where n represents the number of IOs bonded out from a bank.

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Table 3-27 Single-ended I/O DC Characteristics (GW5AT-75)

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS33 LVTTL33	-0.3V	0.8V	2.0V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
							24	-24
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS25	-0.3V	0.7V	1.7V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
							24	-24
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS18	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
							24	-24
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS15	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS12	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	4	-4
							8	-8
							12	-12
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS10	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	1.1V	0.4V	V_{CCIO}-0.4V	1.5	-0.5
PCI33	-0.3V	0.3 x V_{CCIO}	0.5 x V_{CCIO}	V_{CCIO}+0.3	0.1x V_{CCIO}	0.9 x V_{CCIO}	1.5	-0.5

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
SSTL18_II	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	13.4	-13.4
SSTL18_I	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	8	-8
SSTL15	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	13	-13
SSTL135	-0.3V	V_{REF}-0.09V	V_{REF}+0.09V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	13	-13
HSTL18_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	8	-8
HSTL18_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	16	-16
HSTL15_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	8	-8
HSTL15_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCIO}+0.3	0.40V	V_{CCIO}-0.40V	16	-16
HSUL12	-0.3V	V_{REF}-0.13V	V_{REF}+ 0.13V	V_{CCIO}+0.3	0.40	V_{CCIO}-0.40V	0.1	-0.1

Note!

[1] The total DC current limit(sourced and sinked) of all IOs in the same bank: the total DC current of all IOs in the same bank shall not be greater than n*8mA, where n represents the number of IOs bonded out from a bank.

GW5AT-60

Table 3-28 Single-ended I/O DC Characteristics (GW5AT-60)

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS33 LVTTL33	-0.3V	0.8V	2.0V	3.45V	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS25	-0.3V	0.7V	1.7V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS18	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS15	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS12	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS10	-0.3	0.35 x V_{CCIO}	0.65 x V_{CCIO}	1.1V	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
PCI33	-0.3V	0.3 x V_{CCO}	0.5 x V_{CCO}	V_{CCO}+0.3	0.1x V_{CCO}	0.9 x V_{CCO}	1.5	-0.5
SSTL33_I	-0.3V	V_{REF}-0.2V	V_{REF}+0.2V	V_{CCO}+0.3	V_{CCO}/2-0.6	V_{CCO}/2+0.6	8	-8
SSTL33_II	-0.3V	V_{REF}-0.2V	V_{REF}+0.2V	V_{CCO}+0.3	V_{CCO}/2-0.8	V_{CCO}/2+0.8	13.4	-13.4
SSTL25_I	-0.3V	V_{REF}-0.15V	V_{REF}+0.15V	V_{CCO}+0.3	V_{CCO}/2-0.61	V_{CCO}/2+0.61	8	-8
SSTL25_II	-0.3V	V_{REF}-0.15V	V_{REF}+0.15V	V_{CCO}+0.3	V_{CCO}/2-0.81	V_{CCO}/2+0.81	13.4	-13.4
SSTL18_I	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCO}+0.3	V_{CCO}/2-0.47	V_{CCO}/2+0.47	8	-8
SSTL18_II	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCO}+0.3	V_{CCO}/2-0.6	V_{CCO}/2+0.6	13.4	-13.4
SSTL15_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	V_{CCO}/2-0.175	V_{CCO}/2+0.175	8	-8
SSTL135_I	-0.3	V_{REF}-0.09V	V_{REF}+0.09V	V_{CCO}+0.3	V_{CCO}/2-0.15	V_{CCO}/2+0.15	8	-8
SSTL12_I	-0.3	V_{REF}-0.1V	V_{REF}+0.1V	V_{CCO}+0.3	0.2 x V_{CCO}	0.8 x V_{CCO}	0.1	-0.1
HSTL18_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	8	-8

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
HSTL18_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	16	-16
HSTL15_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	8	-8
HSTL15_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	8	-8
HSTL12_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.2 x V_{CCO}	0.8 x V_{CCO}	8	-8
HSUL12	-0.3	V_{REF}-0.13V	V_{REF}+ 0.13V	V_{CCO}+0.3	0.2 x V_{CCO}	0.8 x V_{CCO}	0.1	-0.1

Note!

[1] The total DC current limit(sourced and sinked) of all IOs in the same bank: the total DC current of all IOs in the same bank shall not be greater than n*8mA, where n represents the number of IOs bonded out from a bank.

GW5AT-15

Table 3-29 Single-ended I/O DC Characteristics (GW5AT-15)

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS33 LVTTL33	-0.3V	0.8V	2.0V	3.45V	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS25	-0.3V	0.7V	1.7V	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS18	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
LVCMOS18	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	12	-12
							16	-16
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS15	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
							12	-12
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS12	-0.3V	0.35 x V_{CCIO}	0.65 x V_{CCIO}	V_{CCIO}+0.3	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
							6	-6
							8	-8
					0.2V	V_{CCIO}-0.2V	0.1	-0.1
LVCMOS10	-0.3	0.35 x V_{CCIO}	0.65 x V_{CCIO}	1.1V	0.4V	V_{CCIO}-0.4V	2	-2
							4	-4
PCI33	-0.3V	0.3 x V_{CCO}	0.5 x V_{CCO}	V_{CCO}+0.3	0.1x V_{CCO}	0.9 x V_{CCO}	1.5	-0.5
SSTL33_I	-0.3V	V_{REF}-0.2V	V_{REF}+0.2V	V_{CCO}+0.3	V_{CCO}/2-0.6	V_{CCO}/2+0.6	8	-8
SSTL33_II	-0.3V	V_{REF}-0.2V	V_{REF}+0.2V	V_{CCO}+0.3	V_{CCO}/2-0.8	V_{CCO}/2+0.8	13.4	-13.4
SSTL25_I	-0.3V	V_{REF}-0.15V	V_{REF}+0.15V	V_{CCO}+0.3	V_{CCO}/2-0.61	V_{CCO}/2+0.61	8	-8
SSTL25_II	-0.3V	V_{REF}-0.15V	V_{REF}+0.15V	V_{CCO}+0.3	V_{CCO}/2-0.81	V_{CCO}/2+0.81	13.4	-13.4
SSTL18_I	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCO}+0.3	V_{CCO}/2-0.47	V_{CCO}/2+0.47	8	-8
SSTL18_II	-0.3V	V_{REF}-0.125V	V_{REF}+0.125V	V_{CCO}+0.3	V_{CCO}/2-0.6	V_{CCO}/2+0.6	13.4	-13.4
SSTL15_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	V_{CCO}/2-0.175	V_{CCO}/2+0.175	8	-8
SSTL135_I	-0.3	V_{REF}-0.09V	V_{REF}+0.09V	V_{CCO}+0.3	V_{CCO}/2-0.15	V_{CCO}/2+0.15	8	-8
SSTL12_I	-0.3	V_{REF}-0.1V	V_{REF}+0.1V	V_{CCO}+0.3	0.2 x V_{CCO}	0.8 x V_{CCO}	0.1	-0.1
HSTL18_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	8	-8
HSTL18_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	16	-16
HSTL15_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	8	-8
HSTL15_II	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.40V	V_{CCO}-0.40V	8	-8
HSTL12_I	-0.3V	V_{REF}-0.1V	V_{REF}+ 0.1V	V_{CCO}+0.3	0.2 x V_{CCO}	0.8 x V_{CCO}	8	-8

Name	V_{IL}		V_{IH}		V_{OL} (Max)	V_{OH} (Min)	I_{OL} [1] (mA)	I_{OH} [1] (mA)
	Min	Max	Min	Max				
HSUL12	-0.3	V_{REF}-0.13V	V_{REF}+ 0.13V	V_{CCO}+0.3	0.2 x V_{CCO}	0.8 x V_{CCO}	0.1	-0.1

Note!

[1] The total DC current limit(sourced and sinked) of all IOs in the same bank: the total DC current of all IOs in the same bank shall not be greater than n*8mA, where n represents the number of IOs bonded out from a bank.

3.3.5 Differential I/O DC Characteristic

GW5AT-138

Table 3-30 Differential I/O DC Characteristics (GW5AT-138)

Name	Description	Conditions	Min.	Typ.	Max.	Unit
V_{ICM}	Input Common Mode Voltage	Half the Sum of the Two Inputs	0.05		1.8	V
V_{ID}	Differential Input Threshold	Difference Between the Two Inputs	±100	±350	±600	mV
I_{IN}	Input Current	Power On or Power Off			20	μA
V_{OD}	Output Voltage Differential	(V_{OP} - V_{OM}), R_T = 100Ω	250	350	600	mV
ΔV_{OD}	Change in VOD Between High and Low				50	mV
V_{OS}	Output Voltage Offset	(V_{OP} + V_{OM})/2, R_T = 100Ω	1.000	1.250	1.425	V
ΔV_{OS}	Change in VOS Between High and Low				50	mV
I_S	Short-circuit current	V_{OD} = 0V output short-circuit			12	mA

GW5AT-75

Table 3-31 Differential I/O DC Characteristics (GW5AT-75)

Name	Description	Conditions	Min.	Typ.	Max.	Unit
V_{ICM}	Input Common Mode Voltage	Half the Sum of the Two Inputs	0.05		1.8	V
V_{ID}	Differential Input Threshold	Difference Between the Two Inputs	±100	±350	±600	mV
I_{IN}	Input Current	Power On or Power Off			20	μA

Name	Description	Conditions	Min.	Typ.	Max.	Unit
V_{OD}	Output Voltage Differential	(V_{OP} - V_{OM}), R_T = 100Ω	250	350	600	mV
ΔV_{OD}	Change in VOD Between High and Low				50	mV
V_{OS}	Output Voltage Offset	(V_{OP} + V_{OM})/2, R_T = 100Ω	1.000	1.250	1.425	V
ΔV_{OS}	Change in VOS Between High and Low				50	mV
I_S	Short-circuit current	V_{OD} = 0V output short-circuit			12	mA

GW5AT-60

Table 3-32 Differential I/O DC Characteristics (GW5AT-60)

Name	Description	Conditions	Min.	Typ.	Max.	Unit
V_{ICM}	Input Common Mode Voltage	Half the Sum of the Two Inputs	0.3		2.35	V
V_{ID}	Differential Input Threshold	Difference Between the Two Inputs	±100	±350	±600	mV
I_{IN}	Input Current	Power On or Power Off	–	–	20	μA
V_{OD}	Output Voltage Differential	(V_{OP} - V_{OM}), R_T = 100Ω	250	350	600	mV
ΔV_{OD}	Change in VOD Between High and Low		–	–	50	mV
V_{OS}	Output Voltage Offset	(V_{OP} + V_{OM})/2, R_T = 100Ω	1.125	1.25	1.375	V
ΔV_{OS}	Change in VOS Between High and Low		–	–	50	mV
I_S	Short-circuit current	V_{OD} = 0V output short-circuit	–	–	12	mA

GW5AT-15

Table 3-33 Differential I/O DC Characteristics (GW5AT-15)

Name	Description	Conditions	Min.	Typ.	Max.	Unit
V_{ICM}	Input Common Mode Voltage	Half the Sum of the Two Inputs	0.3		2.35	V
V_{ID}	Differential Input Threshold	Difference Between the Two Inputs	±100	±350	±600	mV

Name	Description	Conditions	Min.	Typ.	Max.	Unit
I_{IN}	Input Current	Power On or Power Off	–	–	20	µA
V_{OD}	Output Voltage Differential	(V_{OP} - V_{OM}), R_T = 100Ω	250	350	600	mV
ΔV_{OD}	Change in VOD Between High and Low		–	–	50	mV
V_{OS}	Output Voltage Offset	(V_{OP} + V_{OM})/2, R_T = 100Ω	1.125	1.25	1.375	V
ΔV_{OS}	Change in VOS Between High and Low		–	–	50	mV
I_S	Short-circuit current	V_{OD} = 0V output short-circuit	–	–	12	mA

3.4 AC Switching Characteristics

3.4.1 CFU Switching Characteristics

Table 3-34 CFU Timing Parameters

Name	Description	C2/I1		C1/I0		Unit
		Min	Max	Min	Max	
t_{LUT4_CFU}	LUT4 delay	0.297	0.539	0.371	0.674	ns
t_{SR_CFU}	Set/Reset to Register output	1.075	1.148	1.344	1.435	ns
t_{CO_CFU}	Clock to Register output	0.200	0.230	0.250	0.288	ns

3.4.2 BSRAM Switching Characteristics

Table 3-35 BSRAM Timing Parameters

Name	Description	C2/I1		C1/I0		Unit
		Min	Max	Min	Max	
t_{COAD_BSRAM}	Clock to read address / data output	1.1	1.47	1.375	1.838	ns
t_{COOR_BSRAM}	Clock to Register output	0.23	0.326	0.288	0.408	ns

3.4.3 DSP Switching Characteristics

Table 3-36 DSP Timing Parameters

Name	Description	C2/I1		C1/I0		Unit
		Min	Max	Min	Max	
t_{COIR_DSP}	Clock to output from input register	0.2	0.22	0.24	0.25	ns
t_{COPR_DSP}	Clock to output from pipeline register	0.06	0.07	0.07	0.08	ns
t_{COOR_DSP}	Clock to output from output register	0.03	0.04	0.04	0.04	ns

3.4.4 Gearbox Switching Characteristics

Table 3-37 Gearbox Timing Parameters

Name	Description	Max.	Unit
$FMAX_{IDDR}$	1:2 Gearbox maximum serial input rate	400	Mbps
$FMAX_{IDES4}$	1:4 Gearbox maximum serial input rate	800	Mbps
$FMAX_{IDESx}$	1:8/1:10 Gearbox maximum serial input rate	1500	Mbps
$FMAX_{IDES14}$	1:14 Gearbox maximum serial input rate	1500	Mbps
$FMAX_{IDES16}$	1:16 Gearbox maximum serial input rate	1500	Mbps

Name	Description	Max.	Unit
$FMAX_{IDES32}$	1:32 Gearbox maximum serial input rate	1500	Mbps
$FMAX_{ODDR}$	2:1 Gearbox maximum serial output rate	400	Mbps
$FMAX_{OSER4}$	4:1 Gearbox maximum serial output rate	800	Mbps
$FMAX_{OSERx}$	8:1/10:1 Gearbox maximum serial output rate	1500	Mbps
$FMAX_{OSERx}$	8:1/10:1 Gearbox maximum serial output rate	1500	Mbps
$FMAX_{OSER16}$	16:1 Gearbox maximum serial output rate	1500	Mbps

3.4.5 On chip Oscillator Switching Characteristics

Table 3-38 On chip Oscillator Switching Characteristics

Name	Description	Min.	Typ.	Max.
f_{MAX}	Output Frequency (0°C to + 85°C)	199.5 MHz	210 MHz	220.5 MHz
	Output Frequency (-40°C to +100°C)	189 MHz	210 MHz	231 MHz
t_{DT}	Output Clock Duty Cycle	-	50%	-

3.4.6 PLL Switching Characteristics

Table 3-39 PLL Switching Characteristics

Parameter	Description	Speed Grade		Unit	Note
		C2/I1	C1/I0		
F_{INMAX}	Maximum Input Clock Frequency	800	800	MHz	
F_{INMIN}	Minimum Input Clock Frequency	19	19	MHz	
F_{PFDMAX}	Maximum Frequency at the Phase Frequency Detector	400	400	MHz	
F_{PFDMIN}	Minimum Frequency at the Phase Frequency Detector	19	19	MHz	
$F_{INJITTER}$	Maximum Input Clock Period Jitter	< 20% of clock input period or 1 ns Max			
F_{INDUTY}	Minimum Allowable Input Duty Cycle: 19–49 MHz	25	25	%	
	Minimum Allowable Input Duty Cycle: 50–199 MHz	30	30	%	
	Minimum Allowable Input Duty Cycle: 200–399 MHz	35	35	%	
F_{VCOMIN}	Minimum PLL VCO Frequency	800	800	MHz	
F_{VCOMAX}	Maximum PLL VCO Frequency	1600	1600	MHz	
F_{BW}	Low PLL Bandwidth at Typical	1	1	MHz	

Parameter	Description	Speed Grade		Unit	Note
		C2/I1	C1/I0		
F_{BW}	High PLL Bandwidth at Typical	4	4	MHz	
$T_{STATPHAOFF-SET}$	Static Phase Offset of the PLL Outputs	+/- 50	+/-50	ps	
$T_{JIT-TER\_CCJ\_HCLK}$	PLL Output cycle-cycle Jitter Thru HCLK≥100MHz	<300	<300	ps	[3]
	PLL Output cycle-cycle Jitter Thru HCLK <100MHz	<30	<30	mUI	
	PLL Output cycle-cycle Jitter Thru PCLK ≥100MHz	<400	<400	ps	
	PLL Output cycle-cycle Jitter Thru PCLK <100MHz	<40	<40	mUI	
$T_{JIT-TER\_PJ\_PCLK}$	PLL Output period Jitter Thru HCLK≥100MHz	<300	<300	ps	
	PLL Output period Jitter Thru HCLK <100MHz	<30	<30	mUI	
	PLL Output period Jitter Thru PCLK ≥100MHz	<400	<400	ps	
	PLL Output period Jitter Thru PCLK <100MHz	<40	<40	mUI	
$T_{OUTDUTY}$	PLL Output Clock Duty Cycle Precision	<50	<50	mUI	[1],[4]
$T_{LOCKMAX}$	PLL Maximum Lock Time	1	1	ms	
F_{OUTMAX}	PLL Maximum Output Frequency	800	800	MHz	
F_{OUTMIN}	PLL Minimum Output Frequency	6.25	6.25	MHz	[2]
$T_{EXTFDVAR}$	External Clock Feedback Variation	< 20% of clock input period or 1 ns Max			
$RST_{MINPULSE}$	Minimum Reset Pulse Width	10	10	ns	

Note!

- [1] This test data is derived from integer frequency divider outputs.
- [2] In Cascade mode, multiple dividers can be serially connected to achieve a reduced output frequency.
- [3] The level of output jitter correlates with the input source; this dataset is based on a low-jitter crystal as the source.
- [4] The observed duty cycle on IOs is influenced by the Clock Tree.

3.5 Gigabit Transceiver

3.5.1 Gigabit Transceiver DC Characteristics

Table 3-40 Gigabit Transceiver DC Characteristics

Name	Description	Condition	Min.	Typ.	Max.	Units
$VOUT_{diff\_p2p}$	Differential peak-to-peak output voltage	Transmitter output swing is set to maximum setting	–	–	V_{dda}	mV
$VOUT_{cm}$	DC common mode output voltage	Equation based		$V_{DDA}/2$		mV
R_{src_term}	Differential output resistance		–	100	–	Ω
$T_{intrapairskew}$	Transmitter output pair (TXP and TXN) intra-pair skew		–	2	12	ps
VIN_{diff_p2p}	Differential peak-to-peak input voltage (external AC coupled)		200	–	2000	mV
VIN	Absolute input voltage	DC coupled V_{DDT} = 0.9V	–300	–	V_{dda}	mV
VIN_{CM}	Common mode input voltage	DC coupled V_{DDT} = 0.9V	–	–	500	mV
R_{Term}	Differential input resistance		–	100	–	Ω
C_{EXT}	Recommended external AC coupling capacitor		–	100	–	nF

3.5.2 Gigabit Transceiver Switching Characteristics

Table 3-41 Transmitter and Receiver Data Transmission Characteristics

Name	Conditions	C2/I1		C1/I0		Unit
		Flip Chip	Wire Bond	Flip Chip	Wire Bond	
On-board applications (chip-chip)[1]	Maximum data rate (Typical Voltage)	12.5	8	10.3125	8	Gbps
	Min. data rate[3]	270	270	270	270	Mbps
Backplane[2]	Maximum data rate (Typical Voltage)	8	8	8	8	Gbps
	Min. data rate[4]	270	270	270	270	Mbps

Note!

- [1] Less channel loss for chip-chip applications.
- [2] For backplane applications, the maximum channel loss should be within the PCIE 3.0 standard.

- [3] [4] Oversampling enabled.

Table 3-42 PLL Specifications

Name	Conditions	C2/I1 / C1/I0		Unit
		Min	Max	
Channel PLL	Recommended Operating Conditions	1.25	6.5	GHz
Quad PLL 0	Recommended Operating Conditions	1.25	6.5	GHz
Quad PLL 1	Recommended Operating Conditions	3.8	6.5	GHz
Output lane divider[1]	1/2/4/8			

Note!

[1] Lower rates can be achieved by using an Output lane divider.

Table 3-43 Reference Clock Switching Characteristics

Name	Description	Conditions	C2/I1 / C1/I0			Units
			Min.	Typ.	Max.	
$F_{GREFCLK}$	Reference clock frequency range		20	–	800	MHz
$T_{RREFCLK}$	Reference clock rise time	20% – 80%	–	200	–	ps
$T_{FREFCLK}$	Reference clock fall time	80% – 20%	–	200	–	ps
$T_{DCREFCLK}$	Reference clock duty cycle	Transceiver PLL only	40	50	60	%

Table 3-44 PLL Lock Time Adaptation

Name	Description	C2/I1 / C1/I0			Units
		Min.	Typ.	Max.	
$T_{GPLLLOCK}$	Initial PLL lock	–	–	2	ms

3.6 MIPI D-PHY

3.6.1 MIPI D-PHY Input Timing and Levels

Table 3-45 High Speed(Differential) Input DC Specification

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{CMRX}	Common-mode Voltage in High Speed Mode	-	70	-	330	mV
V_{IDTH}	Differential Input HIGH Threshold	0.08 Gbps ≦Data-Rate≦1.5 Gbps	70	-	-	mV

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{IDTH}	Differential Input HIGH Threshold	1.5 Gbps ≦Data-Rate≦2.5 Gbps	40	-	-	mV
V_{IDTL}	Differential Input LOW Threshold	0.08 Gbps ≦Data-Rate≦1.5 Gbps	-	-	-70	mV
		1.5 Gbps ≦Data-Rate≦2.5 Gbps	-	-	-40	mV
V_{IHHS}	Input HIGH Voltage(for HS mode)	-	-	-	460	mV
V_{ILHS}	Input LOW Voltage	-	-40	-	-	mV
$V_{TERM-EN}$	Single-ended voltage for HS Termination Enable	-	-	-	450	mV
Z_{ID}	Differential Input Impendance	-	80	100	120	Ω

Table 3-46 High Speed(Differential) Input AC Specification

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
$\triangle V_{CMRX}$(HF)	Common-mode Interference(>450 MHz)	0.08 Gbps ≦Data-Rate≦1.5 Gbps	-	-	100	mV
		1.5 Gbps ≦Data-Rate≦2.5 Gbps	-	-	50	mV
$\triangle V_{CMRX}$(LF)	Common-mode Interference(50MHz~450 MHz)	0.08 Gbps ≦Data-Rate≦1.5 Gbps	-50	-	50	mV
		1.5 Gbps ≦Data-Rate≦2.5 Gbps	-25	-	25	mV
C_{CM}	Common-mode Termination	-	-	-	60	pF

Table 3-47 Low Power(Single-Ended) Input DC Specifications

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{IH}	Low Power Mode Input HIGH Voltage	-	760	-	-	mV
V_{IL}	Low Power Mode Input LOW Voltage	-	-	-	550	mV
V_{HYST}	Low Power Mode Input Hysteresis	-	25	-	-	mV
I_{LEAK}	Pin Leakage Current	-	-100	-	100	uA

3.6.2 MIPI D-PHY Output Timing and Levels

GW5AT-138

Table 3-48 Low Power(Single-Ended) Output DC Specifications (GW5AT-138)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{OH}	Low Power Mode Thevenin Output High Level Voltage	0.08 Gbps ≦ Data-Rate ≦ 1.5 Gbps	1.1	1.2	1.3	V
		DataRate > 1.5Gbps	0.95	-	1.3	mV
V_{OL}	Low Power Mode Thevenin Output Low Level Voltage	-	-50	-	50	mV
Z_{OLP}	Output Impedance in LP mode	-	110	-	-	Ω

Table 3-49 Low Power(Single-Ended) Output AC Specifications (GW5AT-138)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
t_R	15%~85% Rise Time	-	-	-	25	ns
t_F	85%~15% Fall Time	-	-	-	25	ns
t_{REOT}	HS-LP Mode Rise and Fall Time, 30%~85%	-	-	-	35	ns
C_{LOAD}	Load Capacitance	-	0	-	70	pF

GW5AT-75

Table 3-50 Low Power(Single-Ended) Output DC Specifications (GW5AT-75)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{OH}	Low Power Mode Thevenin Output High Level Voltage	0.08 Gbps ≦ Data-Rate ≦ 1.5 Gbps	1.1	1.2	1.3	V
		DataRate > 1.5Gbps	0.95	-	1.3	mV
V_{OL}	Low Power Mode Thevenin Output Low Level Voltage	-	-50	-	50	mV
Z_{OLP}	Output Impedance in LP mode	-	110	-	-	Ω

Table 3-51 Low Power(Single-Ended) Output AC Specifications (GW5AT-75)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
t_R	15%~85% Rise Time	-	-	-	25	ns
t_F	85%~15% Fall Time	-	-	-	25	ns

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
t_{REOT}	HS-LP Mode Rise and Fall Time, 30%~85%	-	-	-	35	ns
C_{LOAD}	Load Capacitance	-	0	-	70	pF

GW5AT-60

Table 3-52 Low Power(Single-Ended) Output DC Specifications (GW5AT-60)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{OH}	Low Power Mode Thevenin Output High Level Voltage	0.08 Gbps ≦Data-Rate≦1.5 Gbps	1.1	1.2	1.3	V
		DataRate > 1.5Gbps	0.95	-	1.3	mV
V_{OL}	Low Power Mode Thevenin Output Low Level Voltage	-	-50	-	50	mV
Z_{OLP}	Output Impedance in LP mode	-	110	-	-	Ω

Table 3-53 Low Power(Single-Ended) Output AC Specifications (GW5AT-60)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
t_R	15%~85% Rise Time	-	-	-	25	ns
t_F	85%~15% Fall Time	-	-	-	25	ns
t_{REOT}	HS-LP Mode Rise and Fall Time, 30%~85%	-	-	-	35	ns
C_{LOAD}	Load Capacitance	-	0	-	70	pF

Table 3-54 High Speed(Differential) Output DC Specifications (GW5AT-60)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{CMTX}	Common-mode Voltage in High Speed Mode	-	150	200	250	mV
$\|V_{CMTX(1,0)}\|$	V_{CMTX} Mismatch Between Differential HIGH and LOW	-	-	-	5	mV
$\|V_{OD}\|$	Differential Output Voltage	|D-PHY-P — D-PHY-N|	140	200	270	mV
$\|\triangle V_{OD}\|$	VOD Mismatch Between Differential HIGH and LOW			-	14	mV
V_{OHHS}	Single-Ended Output HIGH Voltage	-	-	-	360	mV
Z_{OS}	Single-Ended Differential Output Impendance	-	40	50	62.5	Ω

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
$\triangle Z_{OS}$	Z_{OS} mismatch	-	-	-	10	%

Table 3-55 High Speed(Differential) Output AC Specifications (GW5AT-60)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
$\triangle V_{CMTX}$(HF)	Common-mode Variation(>450 MHz)	-	-	-	15	mVrms
$\triangle V_{CMTX}$(LF)	Common-mode Variation(50MHz~450 MHz)	-	-	-	25	mVrms
$t_{HS-PREPARE}$	Time Interval of The Final LP-00 State before enabling HS mode	-	40ns + 4*UI	-	85ns + 6*UI	ns
$t_{HS-PREPARE}$ + $t_{HS-ZERO}$	The Minimum duration of driving the extended Data HS-0 prior to starting HS sysnc sequence	-	145ns + 10*UI	-	-	ns
t_R	20%~80% Rise Time	0.08 Gbps ≦DataRate≦1 Gbps	-	-	0.3	UI
		1 Gbps ≦DataRate≦1.5 Gbps	-	-	0.35	UI
		DataRate≦1.5 Gbps	100	-	-	ps
		1.5 Gbps ≦DataRate≦2.5 Gbps	-	-	0.4	UI
		DataRate>1.5 Gbps	50	-	-	ps
t_F	20%~80% Fall Time	0.08 Gbps ≦DataRate≦1 Gbps	-	-	0.3	UI
		1 Gbps ≦DataRate≦1.5 Gbps	-	-	0.35	UI
		DataRate≦1.5 Gbps	100	-	-	ps
		1.5 Gbps ≦DataRate≦2.5 Gbps	-	-	0.4	UI
		DataRate>1.5 Gbps	50	-	-	ps
$t_{HS-TRAIL}$	The Duration of The Inverted Final Differential State Following The Last Payload Data Bit	-	60ns + 4*UI	-	-	ns
t_{EOT}	Combination of $t_{HS-TRAIL}$ and t_{REOT}	-	-	-	105ns + 12*UI	ns

GW5AT-15

Table 3-56 Low Power(Single-Ended) Output DC Specifications (GW5AT-15)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{OH}	Low Power Mode Thevenin Output High Level Voltage	0.08 Gbps ≦Data-Rate≦1.5 Gbps	1.1	1.2	1.3	V
		DataRate > 1.5Gbps	0.95	-	1.3	mV
V_{OL}	Low Power Mode Thevenin Output Low Level Voltage	-	-50	-	50	mV
Z_{OLP}	Output Impedance in LP mode	-	110	-	-	Ω

Table 3-57 Low Power(Single-Ended) Output AC Specifications (GW5AT-15)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
t_R	15%~85% Rise Time	-	-	-	25	ns
t_F	85%~15% Fall Time	-	-	-	25	ns
t_{REOT}	HS-LP Mode Rise and Fall Time, 30%~85%	-	-	-	35	ns
C_{LOAD}	Load Capacitance	-	0	-	70	pF

Table 3-58 High Speed(Differential) Output DC Specifications (GW5AT-15)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
V_{CMTX}	Common-mode Voltage in High Speed Mode	-	150	200	250	mV
$\|V_{CMTX(1,0)}\|$	V_{CMTX} Mismatch Between Differential HIGH and LOW	-	-	-	5	mV
$\|V_{OD}\|$	Differential Output Voltage	|D-PHY-P — D-PHY-N|	140	200	270	mV
$\|\triangle V_{OD}\|$	VOD Mismatch Between Differential HIGH and LOW			-	14	mV
V_{OHHS}	Single-Ended Output HIGH Voltage	-	-	-	360	mV
Z_{OS}	Single-Ended Differential Output Impendance	-	40	50	62.5	Ω
$\triangle Z_{OS}$	Z_{OS} mismatch	-	-	-	10	%

Table 3-59 High Speed(Differential) Output AC Specifications (GW5AT-15)

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
$\triangle V_{CMTX}(HF)$	Common-mode Variation(>450 MHz)	-	-	-	15	mVrms
$\triangle V_{CMTX}(LF)$	Common-mode Variation(50MHz~450 MHz)	-	-	-	25	mVrms
$t_{HS-PREPARE}$	Time Interval of The Final LP-00 State before enabling HS mode	-	40ns + 4*UI	-	85ns + 6*UI	ns
$t_{HS-PREPARE} + t_{HS-ZERO}$	The Minimum duration of driving the extended Data HS-0 prior to starting HS sysnc sequence	-	145ns + 10*UI	-	-	ns
t_R	20%~80% Rise Time	0.08 Gbps ≦DataRate≦1 Gbps	-	-	0.3	UI
		1 Gbps ≦DataRate≦1.5 Gbps	-	-	0.35	UI
		DataRate≦1.5 Gbps	100	-	-	ps
		1.5 Gbps ≦DataRate≦2.5 Gbps	-	-	0.4	UI
		DataRate>1.5 Gbps	50	-	-	ps
t_F	20%~80% Fall Time	0.08 Gbps ≦DataRate≦1 Gbps	-	-	0.3	UI
		1 Gbps ≦DataRate≦1.5 Gbps	-	-	0.35	UI
		DataRate≦1.5 Gbps	100	-	-	ps
		1.5 Gbps ≦DataRate≦2.5 Gbps	-	-	0.4	UI
		DataRate>1.5 Gbps	50	-	-	ps
$t_{HS-TRAIL}$	The Duration of The Inverted Final Differential State Following The Last Payload Data Bit	-	60ns + 4*UI	-	-	ns
t_{EOT}	Combination of $t_{HS-TRAIL}$ and t_{REOT}	-	-	-	105ns + 12*UI	ns

3.6.3 MIPI D-PHY Switching Characteristics

Table 3-60 MIPI D-PHY RX Switching Characteristics

Speed Grade	Conditions	Fmin (Typical Voltage)	Fmax (Typical Voltage)	Unit
C2/I1	-	-	2.5	Gbps

Speed Grade	Conditions	Fmin (Typical Voltage)	Fmax (Typical Voltage)	Unit
C1/I0	-	-	2.5	Gbps

Table 3-61 MIPI D-PHY TX Switching Characteristics

Speed Grade	Conditions	Fmin (Typical Voltage)	Fmax (Typical Voltage)	Unit
C2/I1	-	-	2.5	Gbps
C1/I0	-	-	2.5	Gbps

3.6.4 Data-Clock Timing Specifications

Table 3-62 Data-Clock Timing Specifications

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
T_{SKEW}(TX)	Data to Clock Skew	0.08 Gbps ≦Data-Rate≦1.5 Gbps	-0.15	-	0.15	UIINST
		1.5 Gbps ≦Data-Rate≦2.5 Gbps	-0.2	-	0.2	UIINST
T_{SETUP}(RX)	Input Data Setup Before CLK	0.08 Gbps ≦Data-Rate≦1.5 Gbps	0.15	-	-	UI
		1.5 Gbps ≦Data-Rate≦2.5 Gbps	0.2	-	-	UI
T_{HOLD}(RX)	Input Data Hold After CLK	0.08 Gbps ≦Data-Rate≦1.5 Gbps	0.15	-	-	UI
		1.5 Gbps ≦Data-Rate≦2.5 Gbps	0.2	-	-	UI
F_{IN}	Input frequency to GPLL for DPHY	-	19	-	400	MHz
UI Instantaneous	UIinst	-	-	-	12.5	ns
UI Variation	△UI	0.08 Gbps ≦Data-Rate≦1.5 Gbps	-0.1	-	0.1	ns
		DataRate > 1.5Gbps	-0.05	-	0.05	ns

3.7 MIPI C-PHY Switching Characteristics

Table 3-63 MIPI C-PHY RX Switching Characteristics

Speed Grade	Conditions	Fmin (Typical Voltage)	Fmax (Typical Voltage[1])	Unit
C2/I1	V_{CC}=0.9V；V_{DDA_MIPI} =1.05V	-	2.3[2]	Gsps
	V_{CC}=0.9V；V_{DDA_MIPI} =0.9V	-	2	Gsps
C1/I0	V_{CC}=0.9V；V_{DDA_MIPI} =1.05V	-	2	Gsps

Speed Grade	Conditions	Fmin (Typical Voltage)	Fmax (Typical Voltage[1])	Unit
C1/I0	V_{CC}=0.9V； V_{DDA_MIPI} =0.9V	-	1.8	Gsps

Note!

[1] Typical Voltages: V_{CC}=0.9V; V_{DDA_MIPI}=0.9V ; V_{DDX_MIPI}=1.8V; V_{DD12_MIPI}=1.2V.

[2] The Fmax of the GW5AT-LV60UG225HC2/I1 and GW5AT-LV60UG225HC1/I0 devices can reach up to 2.5 Gsps.

Table 3-64 MIPI C-PHY TX Switching Characteristics

Speed Grade	Conditions	Fmin (Typical Voltage)	Fmax (Typical Voltage)	Unit
C2/I1	-	-	2.5	Gsps
C1/I0	-	-	2.5	Gsps

3.8 Configuration Interface Timing Specification

GW5AT Series of FPGA Products support mutiple GowinConfig configurations: SSPI, MSPI, Master CPU, Slave CPU, Master SERIAL, Slave SERIAL, and PCIe. For more detailed information, see:

- *UG704, Arora V 138K&75K FPGA Products Programming and Configuration User Guide*
- *UG718, Arora V 60K FPGA Products Programming and Configuration User Guide*
- *UG720, Arora V 15K FPGA Products Programming and Configuration User Guide*

4 Ordering Information

4.1 Part Name

Figure 4-1 Part Naming Examples–ES

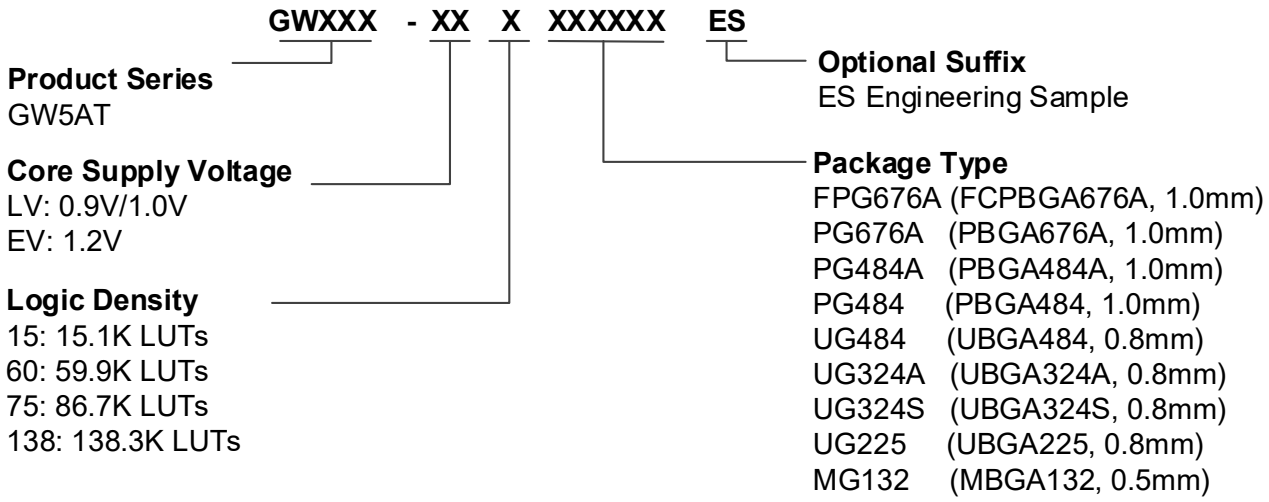
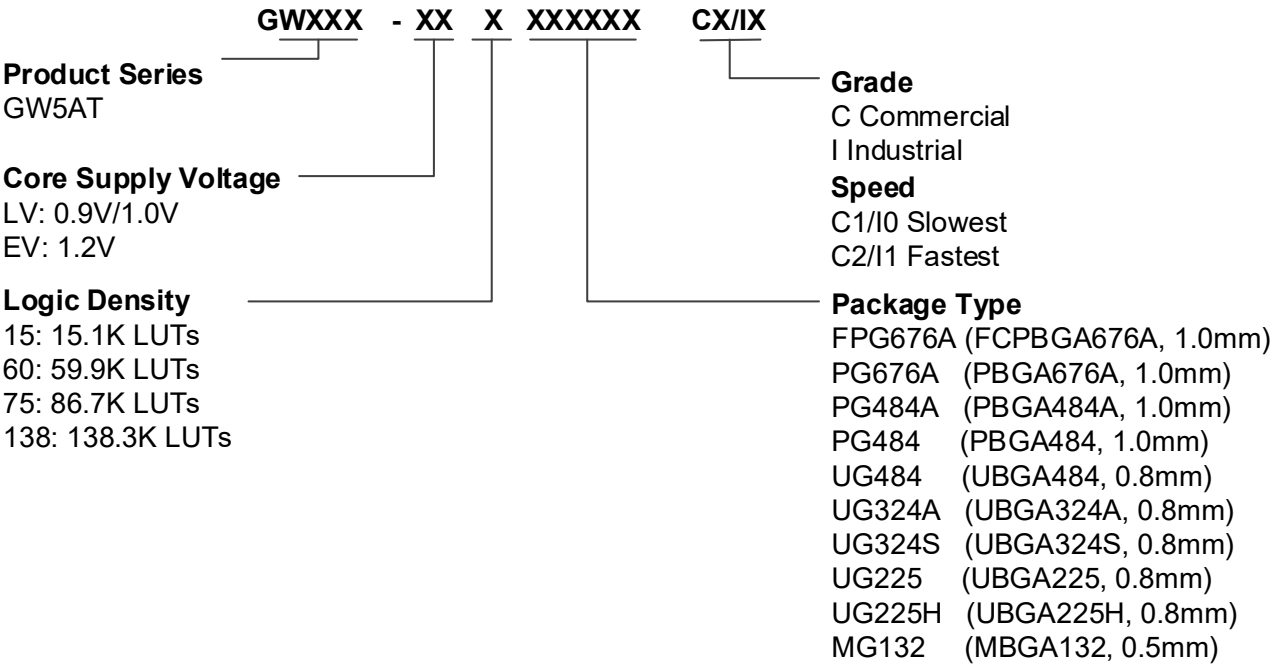


Figure 4-2 Part Naming Examples–Production



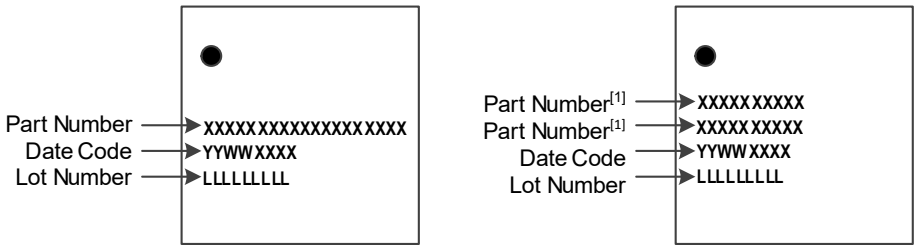
Note!

- For the further detailed information about the package information, please refer to *Product Resources*.
- The LittleBee family devices and Arora family devices of the same speed grade have different speeds.
- Both “C” and “I” are used in GOWIN part name marking for one device, such as C2/I1, C1/I0, etc. GOWIN devices are screened using industrial standards, so one same device can be used for both industrial (I) and commercial (C) applications. The maximum temperature of the industrial grade is 100℃, and the maximum temperature of the commercial grade is 85℃. Therefore, if the same chip meets the speed grade 2 in the commercial grade application, the speed grade is 1 in the industrial grade application.

4.2 Package Mark

The device information of GOWINSEMI is marked on the chip surface, as shown in Figure 4-3.

Figure 4-3 Package Mark Examples



Note!

[1] The first two lines in the right figure above are the “Part Number”.

5 About This Guide

5.1 Purpose

This data sheet describes the features, product resources, structure, AC/DC characteristics, and the ordering information of GW5AT Series of FPGA Products, making it easier for users to understand the products, which will help in the selection and use of the device.

5.2 Related Documents

The latest user guides are available on the GOWINSEMI Website. You can find the related documents at *www.gowinsemi.com*:

- *UG704, Arora V 138K& 75K FPGA Products Programming and Configuration User Guide*
- *UG704, Arora V 60K FPGA Products Programming and Configuration User Guide*
- *UG704, Arora V 15K FPGA Products Programming and Configuration User Guide*
- *UG983, GW5AT Series of FPGA Products Package and Pinout Manual*
- *UG984, GW5AT and GW5AST Series of FPGA Products Schematic Manual*
- *UG982, GW5AT-138 Pinout*
- *UG1221, GW5AT-75 Pinout*
- *UG1222, GW5AT-60 Pinout*
- *UG1224, GW5AT-15 Pinout*

5.3 Terminology and Abbreviations

The terminology and abbreviations used in this manual are as shown in Table 5-1.

Table 5-1 Terminology and Abbreviations

Terminology and Abbreviations	Full Name
ADC	Analog to Digital Converter

Terminology and Abbreviations	Full Name
AER	Advanced Error Reporting
ALP	Adaptive Low Power
ALU	Arithmetic Logic Unit
BSRAM	Block Static Random Access Memory
CFU	Configurable Function Unit
CLS	Configurable Logic Section
CMSER	Configuration Memory Soft Error Recovery
CRU	Configurable Routing Unit
CSI	Camera Serial Interface
CTC	Clock Tolerance Compensation
CTLE	Continuous Time Linear Equalizer
DCS	Dynamic Clock Selector
DFF	D Flip-floor
DNA	Device Identifier
DNL	Differential Non-Linearity
DP	True Dual Port 16K BSRAM
DSI	Display Serial Interface
DSP	Digital Signal Processing
ECC	Error Correction Code
ECRC	End-to-End Cyclic Redundancy Check
ESD	Electro-Static Discharge
FIFO	First In First Out
FPG	FCPBGA
FPGAs	Field Programmable Gate Array
GCLK	Global Clock
GPIO	Gowin Programmable IO
GSR	Global Set/Reset
HCLK	High Speed Clock
HS	High Speed
INL	Integral Non-Linearity
IOB	Input/Output Block
LP	Low Power
LUT	Look-up Table

Terminology and Abbreviations	Full Name
LW	Long Wire
mDRP	Mini Dynamic Re-Program Port
MIPI	Mobile Industry Processor Interface
OTP	One Time Programmable
PCIe	Peripheral Component Interface Express
PCS	Physical Coding Sublayer
PLL	Phase-locked Loop
PMA	Physical Medium Attachment Sublayer
REG	Register
SDP	Semi Dual Port 16K BSRAM
SEU	Single Event Upset
SP	Single Port 16K BSRAM
SSRAM	Shadow Static Random Access Memory
TDM	Time Division Multiplexing

5.4 Support and Feedback

Gowin Semiconductor provides customers with comprehensive technical support. If you have any questions, comments, or suggestions, please feel free to contact us directly using the information provided below.

Website: *www.gowinsemi.com*

E-mail: *support@gowinsemi.com*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