IQX Family Data Sheet

FEATURES

- SRAM-based, in-system programmable
- Switch Matrix
  - Non-Blocking
  - Identical and predictable delays
  - One-to-one, one-to-many and many-to-one connections
- RapidConfigure™ parallel interface for fast, incremental configuration of Switch Matrix and I/O Port attributes
  - 100% JTAG compliant
- Clocked, Latched and Flow-through Dataflow Modes
  - As low as 7.5 ns pin-to-pin delay in flow-through mode and 133 MHz clock rate in registered mode
- I/O Ports
  - Individually programmable as input, output or bidirectional
  - For each I/O Port, clock, clock enable, input enable and output enable can be selected independently from a large pool of common control signals
  - 12 mA current drive
  - Separated I/O power pins for easy interfacing between 5V and 3.3V signals

DESCRIPTION

The IQX family of SRAM-based bit-oriented switching devices is manufactured using a 0.6µm CMOS process. These devices offer clock speeds of up to 133 MHz and pin-to-pin delay as low as 7.5 ns.

The IQX devices are used in applications requiring dynamic switching and flexible routing / interconnection of signals. These applications include communication switches, network systems, DSP / image processing engines and file/video servers.

At the heart of IQX devices is a non-blocking Switch Matrix. A line in the Switch Matrix can be connected to one or more other lines. The Switch Matrix lines are connected to I/O Ports with programmable functional attributes.

The RapidConfigure parallel interface allows connections in the Switch Matrix to be changed quickly and incrementally. This interface can also be used to configure I/O Port attributes individually and incrementally. In either case, data integrity is maintained on all unchanged signal paths through the device.

The IQX devices support the industry standard JTAG (IEEE 1149.1) interface for boundary scan testing. The same interface can also used for serially downloading the configuration bit stream into the devices.

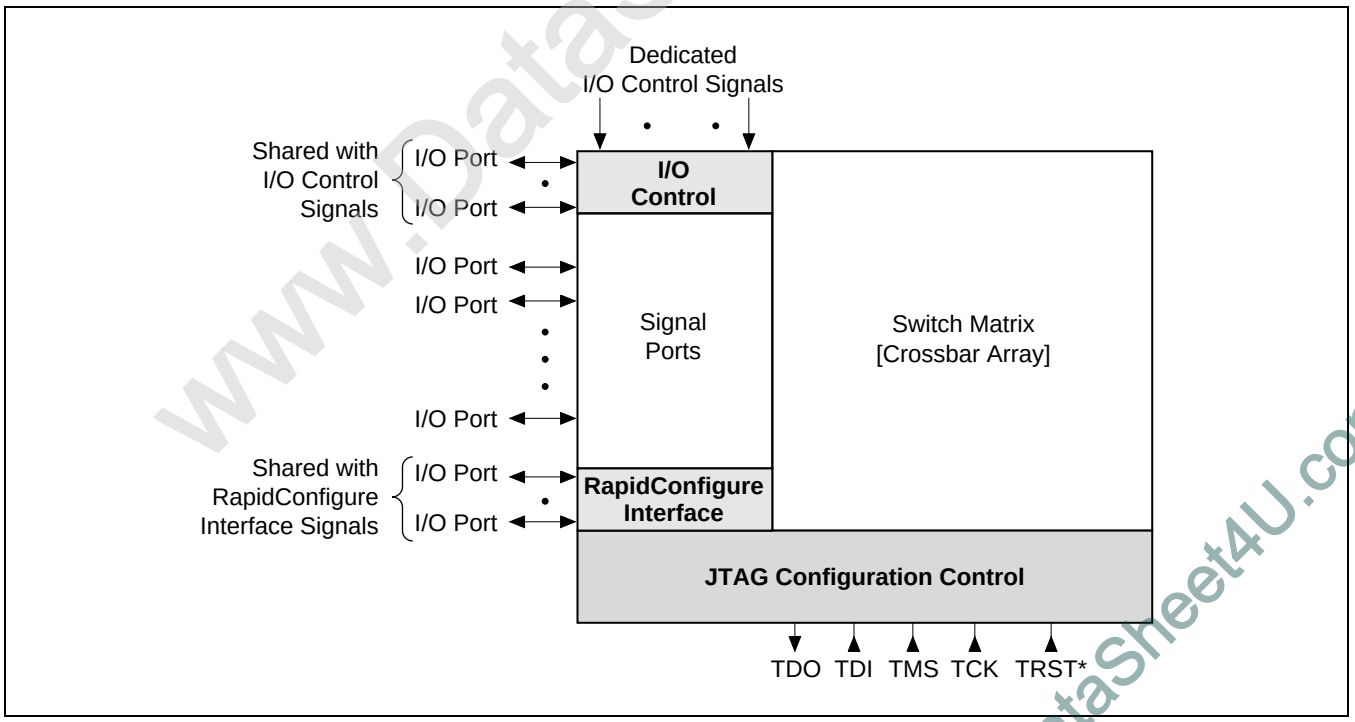

Figure 1. IQX Functional Block Diagram

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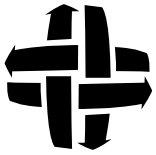

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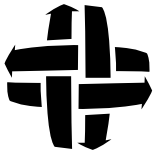

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1.0 ARCHITECTURE

IQX devices are SRAM-based bit-oriented switching matrices. The devices can be configured and controlled in-system by storing appropriate data into the internal SRAM cells and configuration registers. As shown in Figure 1, the main functional blocks of the device are the non-blocking Switch Matrix, Programmable I/O Ports, I/O Control signal block, RapidConfigure Configuration Interface and a JTAG-based Configuration Controller.

The full-featured programmable I/O Ports are connected to the corresponding lines in the Switch Matrix. The I/O Port control signals such as clock, clock enable, input enable, and output enable are used to control the flow of data through the I/O Ports.

The JTAG-based configuration controller is used to download the configuration bit stream serially into the I/O Port configuration registers and Switch Matrix SRAM cells, thereby establishing the desired functional attributes for the I/O Ports and connections among them through the Switch Matrix. Alternatively, the RapidConfigure parallel interface may be used to load the configuration data in the I/O Port Configuration Registers and Switch Matrix SRAM cells. The use of RapidConfigure interface enables quick configuration changes.

1.1 Non-blocking Switch Matrix

The Switch Matrix is an x-y routing structure (or grid). Each horizontal signal trace is *hardwired* to a corresponding vertical signal trace as shown by the junction dots in Figure 2. An I/O Port pin connects to this horizontal-vertical trace pair through a programmable buffer. Signal paths through the Switch Matrix are very well balanced, resulting in predictable and uniform pin-to-pin delays.

A pass transistor whose ON/OFF state is controlled by a dedicated SRAM cell is placed at the intersection of two different signal lines. Signal multicasting/broadcasting operation is supported by allowing a Switch Matrix line carrying an incoming signal to be connected to multiple Switch Matrix lines carrying outgoing signals. Signal multiplexing is supported by allowing multiple Switch Matrix lines carrying incoming signals (controlled using input enable signals) to be connected to the same Switch Matrix line carrying an outgoing signal. It is also possible to create a common internal node among multiple Switch Matrix lines by making all pair-wise connections among these signal lines, and driving such a node by configuring the corresponding I/O Ports in the Bus Repeater mode. Refer to the section on “I/O Port Functional Mode” for more details.

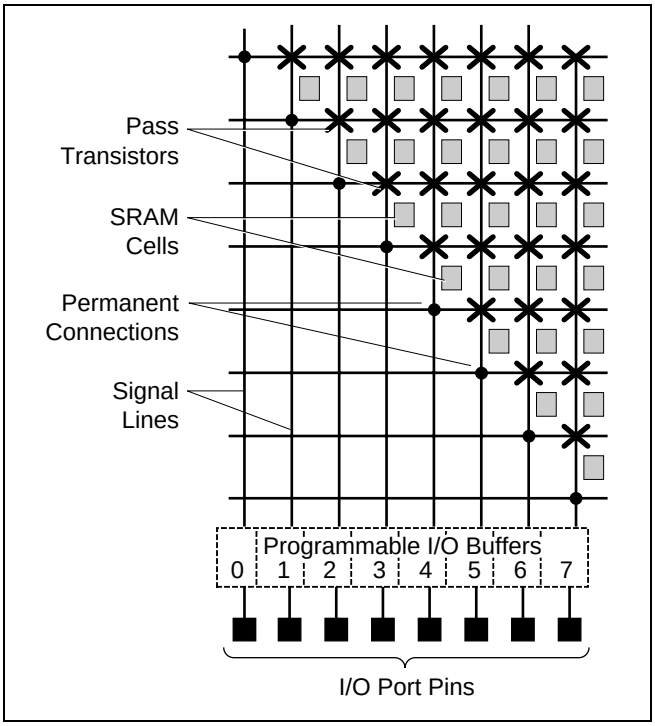


Figure 2. Switch Matrix Structure

1.1.1 Switch Control

As shown in Figure 3, there are two possible switch and SRAM cell locations for a connection between any two Switch Matrix lines. For example, the two possible switch (and SRAM cell) locations controlling a connection between signal lines i and j are row i (word i) and column j (bit j), or row j and column i. Only one location is populated with a switch and the controlling SRAM cell. This location is called the *real* location while the other one is referred to as the *ghost* location. The real cell locations form a unique pattern on the device die as described in Appendix A. The section on “RapidConfigure Interface” explains how this knowledge can be used to reduce the time it takes to change Switch Matrix connections.

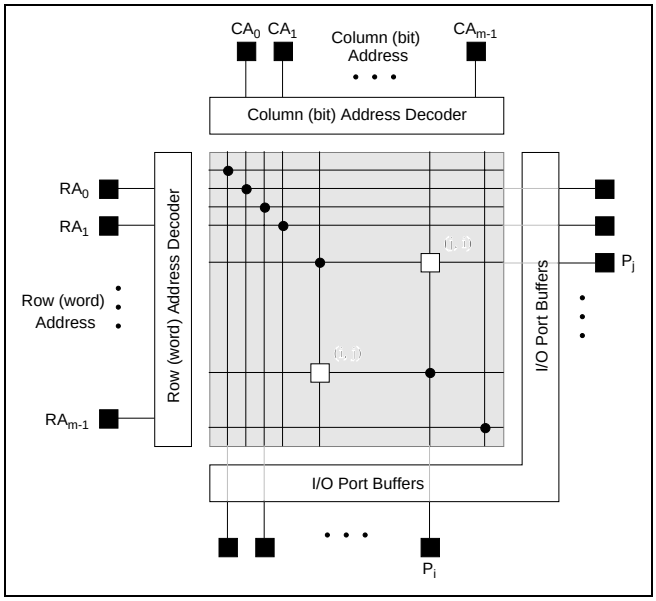


Figure 3. Switch Matrix Control

1.2 Programmable I/O Port

Each signal line in the Switch Matrix is connected to a programmable I/O Port. The functional attributes of individual I/O Ports can be programmed independently. The I/O Port attributes include its signal direction (in, out or bidirectional), data flow mode (flow-through, registered or latched), and pull-up current. Figure 4 shows the structure of the programmable I/O Port. The sources for the four control signals: clock (CLK), clock enable (CKE), input enable (IE), and output enable ($\overline{OE}$) are also programmable and are described later in the section "I/O Control Signals."

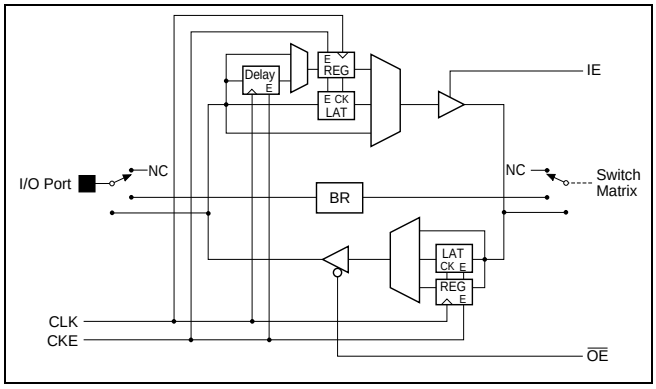


Figure 4. Programmable I/O Port

1.2.1 Programmable Pull-up Current

As shown in Figure 5, the I/O Port contains several n-channel pull-up devices. The normal pull-up current is supplied by a device which is switched on/off by internally generated control signal.

An additional *static* pull-up current (I_{PU-WK}) or (I_{PU-SG}) can be programmed at each I/O Port pin. This additional pull-up current is primarily used for but not restricted to the Bus Repeater (BR) mode.

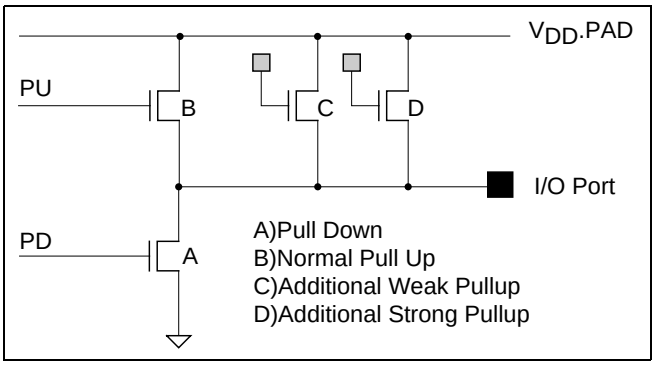


Figure 5. IQX Output Driver and Pull-Up Current

1.2.2 Pin and Array Side Trickle Current

N-channel devices are used as a trickle current source (nominally 10µA) on the pin side and array side for each I/O Port. Upon reset, these current sources are turned ON. They can be turned OFF by configuring the I/O Port.

1.2.3 I/O Port Functional Mode

Table 1 describes the various modes of the I/O Port and the specification used by the I-Cube Development System Software for proper bit stream generation.

Legend:
Ax -Switch Matrix Signal
Px -I/O Port Signal
IE -Input Enable
$\overline{OE}$ -Output Enable
CLK -Clock
CKE - Clock Enable

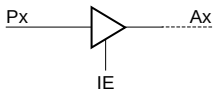
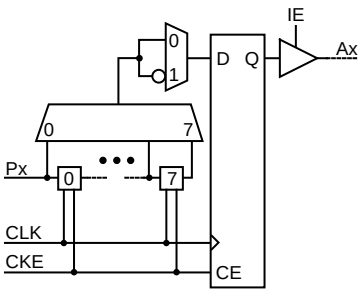
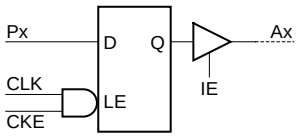
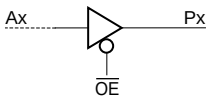
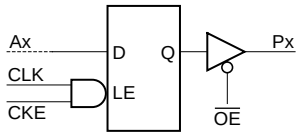
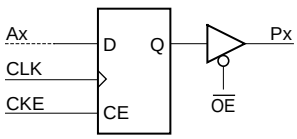
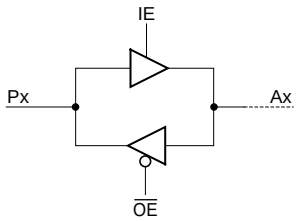
Symbol	I/O Port Function	Mnemonic
	**Input** - The external signal is buffered from the I/O Port pin to the corresponding Switch Matrix line. In this mode an optional input enable (IE) can be selected. Either polarity can be selected for IE. The default level is a logic 1.	IN
	**Registered Input (**with variable length shift register and inversion) - The external signal at the I/O Port pin is registered into a 7-bit edge-triggered shift register within the I/O Port. An 8-to-1 mux selects either the input (bit 0) or one of the 7 output bits of the shift register and connects it to the corresponding signal line in the Switch Matrix through a register. Any tap on the shift register can be selected. The true or complement of the incoming signal can be selected. The default is bit 0, true value. A clock source is required in this mode. Either edge of CLK can be selected. The default for CLK is rising edge. A clock enable (CKE) and input enable (IE) are also available but not required. Either polarity can be selected for IE and CKE. The default level for IE and CKE is a logic 1. The outputs of the shift register are unknown after hardware reset (TRST* = 0).	RI& [bit = value]& [INV = value]
	**Latched Input** - The external signal at the I/O Port pin is latched by a level-sensitive flip-flop within the I/O Port. A latch enable source is required in this mode. The latch enable source is composed of CLK and CKE, and at least one must be specified. An input enable (IE) is also available but not required. Either polarity can be selected for CLK, CKE and IE. The default level for all three is a logic 1. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	LI
	**Output** - The internal signal is buffered from the corresponding Switch Matrix line to the I/O Port pin. In this mode an optional output enable ($\overline{OE}$) can be selected. Either polarity can be selected for OE. The default level is a logic 0.	OP
	**Latched Output**- The internal signal on the Switch Matrix line is latched by a level-sensitive flip-flop within the I/O Port. A latch enable source is required in this mode. The latch enable source is composed of CLK and CKE, and at least one must be specified. An output enable ($\overline{OE}$) is also available but not required. Either polarity can be selected for CLK and CKE. The default level for both is a logic 1. Either polarity can be selected for $\overline{OE}$. The default level is a logic 0. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	LO
	**Registered Output** - The internal signal on the Switch Matrix line is registered by an edge-triggered flip-flop within the I/O Port. A clock source is required in this mode. Either edge of CLK can be selected. The default for CLK is rising edge. A clock enable (CKE) and output enable ($\overline{OE}$) are also available but not required. Either polarity can be selected for CKE and $\overline{OE}$. The default level for CKE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	RO
	**Bidirectional Transceiver** - In this mode, the I/O buffer acts as a bidirectional transceiver between the I/O Port pin and the corresponding Switch Matrix line. This mode requires an input enable (IE) and output enable ($\overline{OE}$). Either polarity can be selected for each but the default level for IE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. When the same source (with default polarities) is used for IE and $\overline{OE}$, it effectively acts as direction control. When the same control signal (with one polarity inverted) is used for IE and $\overline{OE}$, it effectively acts as a Bus Repeater (BR) (see below) when both are enabled, and as No Connect (NC) when neither is enabled.	BT

Table 1. Summary of Programmable I/O Attributes for IQX Devices

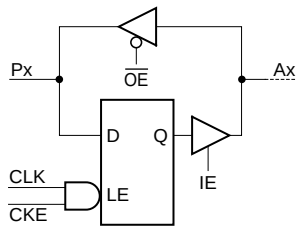
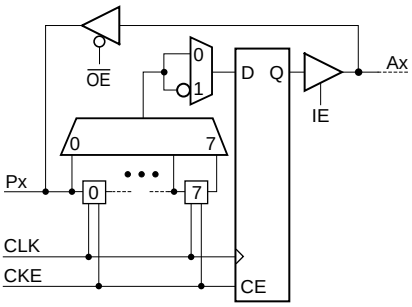
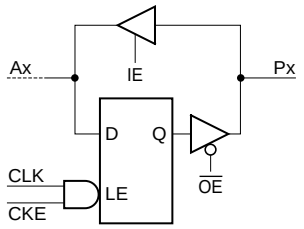
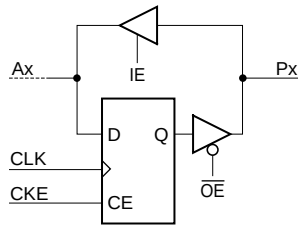
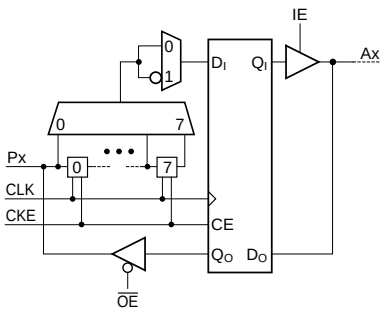
Symbol	I/O Port Function	Mnemonic
	**Bidirectional Transceiver with Latched Input** - This mode combines Latched Input (LI) and output buffer (OP). A latch enable source is required in this mode. The latch enable source is composed of CLK and CKE, and at least one must be specified. Either polarity can be selected for CLK and CKE. The default level for both is a logic 1. This mode also requires an input enable (IE) and output enable ($\overline{OE}$). Either polarity can be selected for IE and $\overline{OE}$. The default level for IE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	BT&LI
	**Bidirectional Transceiver with Registered Input** - This mode combines Registered Input with programmable tap and inversion (RI) and buffered Output (OP). A clock source is required in this mode. Either edge of CLK can be selected. The default for CLK is rising edge. A clock enable (CKE) is available but not required. Either polarity can be selected. The default level for CKE is a logic 1. This mode also requires an input enable (IE) and output enable ($\overline{OE}$). Either polarity can be selected for each. The default level for IE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	BT&RI& [bit = value]& [INV = value]
	**Bidirectional Transceiver with Latched Output** - This mode combines Latched Output (LO) and input buffer (IN). A latch enable source is required in this mode. The latch enable source is composed of CLK and CKE. At least one must be specified. Either polarity can be selected for CLK and CKE. The default level for both is a logic 1. This mode also requires an input enable (IE) and output enable ($\overline{OE}$). Either polarity can be selected for IE and $\overline{OE}$. The default level for IE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	BT&LO
	**Bidirectional Transceiver with Registered Output** - This mode combines Registered Output (RO) and buffered Input (IN). A clock source is required in this mode. Either edge of CLK can be selected although the default is rising edge. A clock enable (CKE) is available but not required. Either polarity can be selected but the default level is a logic 1. This mode also requires an input enable (IE) and output enable ($\overline{OE}$). Either polarity can be selected for IE and $\overline{OE}$. The default level for IE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. The output of the flip-flop is unknown after hardware reset (TRST* = 0).	BT&RO
	**Bidirectional Transceiver with Registered I/O**- This mode is a combination of Registered Input (RI) with programmable tap and inversion, and Registered Output (RO). A clock source is required in this mode. Either edge of CLK can be selected. The default is rising edge. A clock enable (CKE) is available but not required. Either polarity can be selected for CKE. The default level is a logic 1. This mode also requires an input enable (IE) and output enable ($\overline{OE}$). Either polarity can be selected for IE and $\overline{OE}$. The default level for IE is a logic 1 and the default level for $\overline{OE}$ is a logic 0. The output of the flip-flops is unknown after hardware reset (TRST* = 0).	BT&RI& [bit = value]& [INV = value] &RO
	Other BT Modes- Other combinations of I/O Port modes (not covered in this table) are less likely but can be used. The mnemonic is BT [&RI | &LI] [&RO | &LO], where the specification inside the brackets "[ ]" is optional and "|" stands for either or. Insure that control signal requirements are met. In these modes, the output of the flip-flops is unknown after hardware reset (TRST* = 0).	

Table 1. Summary of Programmable I/O Attributes for IQX Devices *(Continued)*

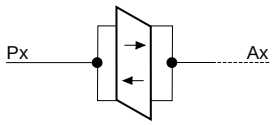
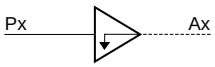
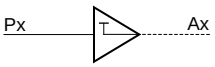
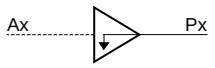
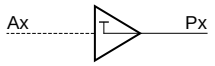
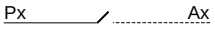
Symbol	I/O Port Function	Mnemonic
	**Bus Repeater** - In the Bus Repeater mode, the I/O Port behaves as a wire (with a non-zero propagation delay). This unique feature patented by I-Cube incorporates a self-sensing circuit to determine signal direction and does not require a direction control signal. When multiple I/O Ports, configured as "Bus Repeater", are connected together through the Switch Matrix to form a single internal node, an (open collector or tristatable) external signal appearing at any one of the I/O Ports gets repeated (or broadcast) to other I/O Ports. The Bus Repeater mode requires a pull-up current source (see section on "Programmable Pull-Up Current") to operate properly. For more details, refer to the Technical Note: "The Bus Repeater Mode."	BR
	**Array Side Force 0** - In this input mode, the Switch Matrix line is forced low (logic 0), regardless of the signal on the corresponding I/O Port. In this mode an optional input enable (IE) can be selected. Either polarity can be selected for IE. The default level is a logic 1.	A0
	**Array Side Force 1** - In this input mode, the Switch Matrix line is forced high (logic 1), regardless of the signal on the corresponding I/O Port. In this mode an optional input enable (IE) can be selected. Either polarity can be selected for IE. The default level is a logic 1.	A1
	**Pin Side Force 0** - In this output mode, the I/O Port pin is forced low (logic 0), regardless of the signal on the corresponding Switch Matrix line. In this mode an optional output enable ($\overline{OE}$) can be selected. Either polarity can be selected for $\overline{OE}$. The default level is a logic 0.	F0
	**Pin Side Force 1** - In this output mode, the I/O Port pin is forced high (logic 1), regardless of the signal on the corresponding Switch Matrix line. In this mode an optional output enable ($\overline{OE}$) can be selected. Either polarity can be selected for $\overline{OE}$. The default level is a logic 0.	F1
	**No Connect** - In this mode, the I/O Port pin is isolated from the Switch Matrix. This is done by tristating both the input and output part of the I/O buffer.	NC

Table 1. Summary of Programmable I/O Attributes for IQX Devices *(Continued)*

1.3 I/O Control Signals

The IQX family has a structure that gives the user a lot of flexibility in controlling the behavior of each I/O Port. As shown in Figure 6 and described below, Clock (CLK), Clock Enable (CKE), Input Enable (IE) and Output Enable ($\overline{OE}$) signals for each I/O Port can be selected from multiple sources. The control polarity can also be individually selected.

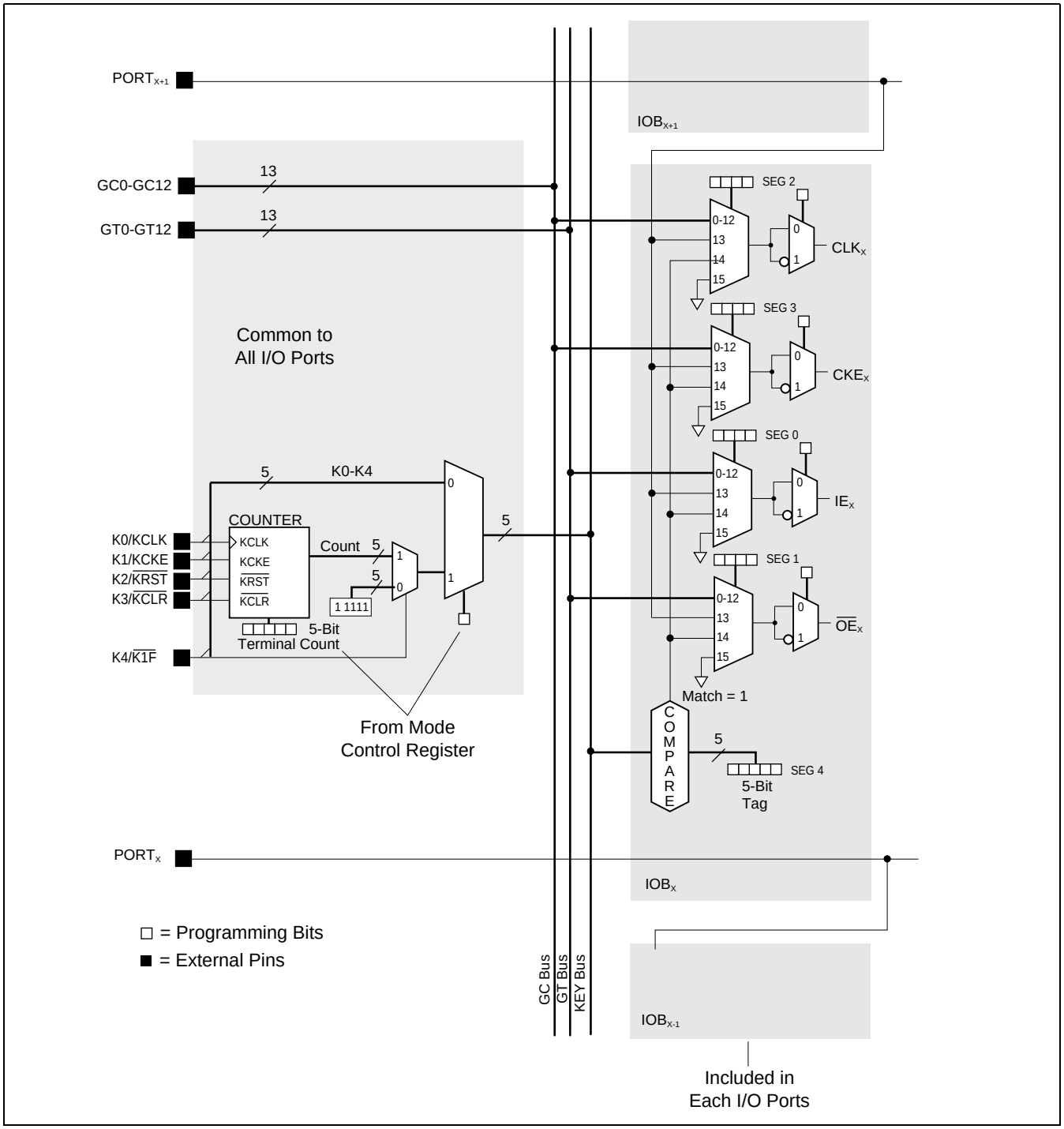


Figure 6. I/O Control

1.3.1 Clock Control

An I/O Port can be individually programmed to select its clock (CLK) and clock enable (CKE) signals from sixteen sources. The source can either be the two (four for IQX320 only) dedicated pins - GC0 and GC1 (GC0 through GC3 for IQX320), 11 (9 for IQX320) clock pins that are shared with signal I/O pins - GC2 through GC12 (GC4 through GC12 for IQX320), the nearest neighboring I/O Port, or the MATCH signal generated using Key Control (K0 - K4) pins.

1.3.2 Tristate Control

An I/O Port can be individually programmed to select its Input Enable (IE) and Output Enable ($\overline{OE}$) signals from sixteen signals. The source can either be the four (five for IQX320 only) dedicated tristate pins - GT0 through GT3 (GT0 through GT4 for IQX320), nine (eight for IQX320) tristate pins that are shared with signal I/O pins - GT4 through GT12 (GT5 through GT12 for IQX320), the nearest neighboring I/O Port, or the MATCH signal generated using Key Control (K0 - K4) pins.

1.3.3 Neighboring I/O Port As A Control Source

A physically adjacent I/O Port on the die can be used as a source for any of the I/O control signals. Port 1 is the control source for Port 0, Port 2 is the control source for Port 1 and so on. Port 0 is the control source for the highest number I/O Port on the device *die*. Note that due to bondout restrictions the neighboring I/O Port may not always be brought out to a package pin on the IQX240B and IQX128B devices.

1.3.4 Key Control Pins as a Control Source

The Key Control feature on the IQX devices allows the user to encode mutually exclusive control signals for use as I/O control signals. The Key pins, K0 through K4 are shared with I/O Ports. This feature, shown schematically in Figure 6, works as follows:

Each I/O Port contains a 5-bit *tag* which can be programmed with a unique value when the I/O Ports are configured. A comparator in each I/O Port continuously compares the programmed tag value with the signals present on the Key pins or the output of the internal 5-bit counter. The output of the comparator, which produces a logic 1 on a match, can be selected as a control signal.

The Key Control is intended for use with level sensitive signals such as IE, $\overline{OE}$, CKE (in registered modes only). If Key Control is used in situations where a short glitch on the internal "Match" signal is unacceptable (i.e., using the Key Port for CLK in *registered* modes and CLK and/or CKE in *latched* modes), it is recommended that one of the Key pins be used as a qualifier and its value changed after the other Key pins have stabilized to prevent glitches on the internal "Match" signal. Note that when key match is used as Output Enable ($\overline{OE}$) the match will disable the driver, while a non-match will enable it. This can be reversed by configuring the I/O Port to use reverse polarity for $\overline{OE}$.

Depending on the value of the Counter Enable bit in the Mode Control Register (see Table 10, the key input to the 5-bit comparator comes either directly from the Key Pins (K0 through K4) or from the output of an internal 5-bit *up* counter. If the counter is selected by setting the Counter Enable bit to a logic 1, the Key pins serve as control inputs to the counter as described below.

K0/KCLK - Counter Clock input

K1/KCKE - Counter Clock Enable

K2/$\overline{KRST}$ - Counter (Synchronous) Reset

K3/$\overline{KCLR}$ - Counter (Asynchronous) Clear

K4/K1F - Counter Select "1F" Hex

The counter is a 5-bit modulo up counter controlled by the rising edge on the counter clock pin (KCLK). It counts up to the 5-bit value programmed in the Mode Control Register and then resets to zero on the following clock edge. KCKE pin is used to qualify the clock. Clocking is enabled when KCKE is high and disabled when low. When the K1F pin is asserted (high), the output of the counter is forced to "11111" regardless of the internal count. During this time the counter continues to count up in response to the clock input. When the $\overline{KRST}$ pin is asserted, the counter is reset on the following clock edge. $\overline{KCLR}$ on the other hand is an asynchronous clear. When asserted, the counter is immediately reset to zero. When the device is reset, the Counter Enable bit and the five Count Value bits are reset to zero.

1.3.5 Default Values for Control Signals

When the device is reset all I/O Ports are set to the default configuration of flow-through input (IN), This is achieved by setting the 16-to-1 muxes shown in Figure 6, to select input 15 (V_{SS}); while the 2-to-1 muxes used for polarity selections are set to select non-inverted value for Clock (CLK) and Clock Enable (CKE), and inverted value for Input Enable (IE) and Output Enable ($\overline{OE}$).

1.4 RapidConfigure (RC) Interface

The RapidConfigure (RC) Interface allows Switch Matrix connections and I/O Port configurations to be changed quickly. A single Switch Matrix connection can be made or broken in a single RapidConfigure cycle; while a single I/O Port or group of

2, 4, 8 or 16 I/O Ports (having the same configuration) can be configured in a minimum of one or maximum of eight RapidConfigure cycles.

The RapidConfigure interface shown in Figure 7 is a write only interface. Its operation is some what similar to a memory write cycle in a microprocessor system - it uses address, data and control signals to write to the Switch Matrix SRAM cells and I/O Port configuration registers. The Control bus, {P/$\overline{S}$ (Port/$\overline{Switch}$), C[1:0]} defines the type of operation performed by the RapidConfigure cycle, while the Row Address, RA[m-1:0], and Column Address, CA[m-1:0], provide the necessary addresses and/or data for the different operations. The value "m" is different for different devices as shown in Table 2. $\overline{WE}$ (Write Enable) acts as chip select while $\overline{STROBE}$ is the write strobe.

Feature	IQX320	IQX240B	IQX160	IQX128B
Total Number of I/O Ports	320	240	160	128
I/O Ports Used for RC Interface[1]	23 / 22	23 / 22	21/20	19/18
Row Address and Column Address Bus Widths	9	9	8	7
I/O Ports whose connections can be changed using RC interface[2]	298	218	140	102

Table 2. RapidConfigure Interface Pin Count

Notes:

1. The IQ compatibility mode uses the lower of the two numbers shown.
2. Due to the requirements for compatibility with the IQ Family and/or bondout restrictions, this number is lower than (# in row 1 - # in row 2) for some devices.

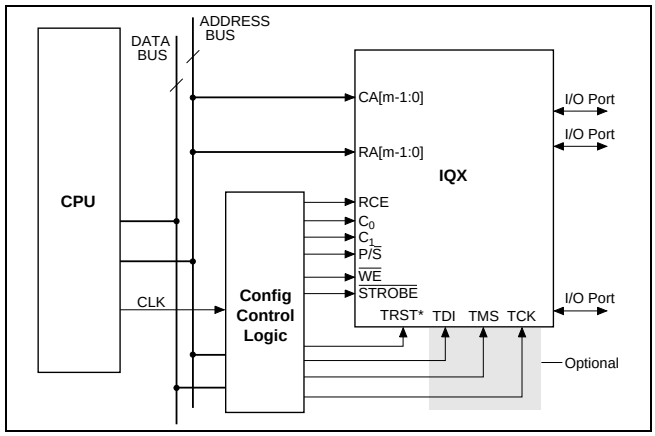


Figure 7. IQX RapidConfigure System Interface

In a typical system, an embedded processor will compute the required Row Address, Column Address and Control values and apply them to the IQX device. Alternatively, these values could be computed before hand using the I-Cube supplied development system software (IDS100), and stored in a lookup table.

The RapidConfigure mode is enabled or disabled by correctly setting the RC *bit* in the Mode Control Register. Table 3 shows the different RapidConfigure options, depending on the values of the "RC" and "RM" *bits* in the Mode Control Register. During hardware reset (TRST* = 0) these bits are set to the signal value on the "RCE" (RapidConnect Enable) *pin*. The values of these *bits* can then be changed if required using the JTAG serial interface. Note that the "P/$\overline{S}$" signal shown in Figure 7 is required only if the RapidConfigure interface is used for changing I/O Port configuration, i.e., when RC *bit* = 1 and RM *bit* = 1. The pin is available for use as signal I/O pin (I/O Port) when RM bit = 0. Table 8 summarizes the different options. Compatibility with the IQ family devices is achieved by connecting the RCE *pin* to V_{SS} on the board.

RC Bit	RM Bit	Operation
0	0	RapidConfigure Mode is disabled. The device can only be configured using the JTAG-based serial interface. In this mode, the I/O Ports used for RapidConfigure Interface can be used for as signal I/O Ports.
1	0	RapidConfigure Mode is enabled for changing Switch Matrix connections but not for I/O Port configuration. The I/O Ports can only be configured using the JTAG-based serial interface. In this mode, the signal coming from the P/$\overline{S}$ pin is forced low internally. The P/$\overline{S}$ pin is available as a signal I/O Port.
1	1	RapidConfigure Mode is enabled for changing Switch Matrix connections and I/O Port configurations.

Table 3. RapidConfigure Options

The user must ensure that the I/O Ports used for the RapidConfigure interface are in the Input (IN) mode and any connections to corresponding signal lines in the Switch Matrix are cleared before attempting to configure the device using this interface. During device reset, the I/O Ports used for the RapidConfigure interface are set to the required Input (IN) and all connections in the Switch Matrix are cleared.

1.4.1 Switch Matrix Connection Changes

As indicated earlier, the Switch Matrix SRAM cells that control the connections among I/O Ports form a two dimensional array. Every SRAM cell location in the Switch Matrix that is being written to is uniquely identified by its Row (or Word) Address and Column (or Bit) Address. The *real* SRAM cell responsible for the connection between two I/O Port numbers "i" and "j" on the

device *die* has the Row Address of Binary (i) and Column Address of Binary (j), or vice versa. Furthermore, when dealing with the bondout devices IQX240B and IQX128B the I/O Port numbers on the device *package* must first be mapped to the I/O Port number on the device *die* to determine the Row and Column Address of the *real* SRAM cell. Refer to Appendix A for the tables and decision logic used to determine the location of the real SRAM cell, and the mapping of I/O Port numbers on the device package to I/O Port numbers on the device die.

The Control bus, {P/$\overline{S}$=0, C[1:0]} specifies the type of connection change, either make or break; the Row and Column Addresses are the values corresponding to the two I/O Port numbers as determined using the tables in Appendix A. P/$\overline{S}$ is set to 0 when changing Switch Matrix connections using RapidConfigure.

As indicated in Table 4, when the control bit C1 is held low during a make or break operation, the remaining SRAM cells belonging to the word addressed by the Row Address are automatically cleared. This feature can be used to speed up connection changes as described below.

In one common crossbar application, the signal I/O Ports on the device are divided into equal groups of inputs and outputs, and a pin in the output group is required to be connected to any pin in the input group. By judicious assignment of the I/O Ports to the output group, one can ensure that for *every* output port, the *real* SRAM cells controlling the connection between that output port and *all* ports in the input group fall on the word corresponding to the output port number. With this assignment, when establishing a new connection using RapidConfigure, any existing connection to that output I/O Port is automatically broken (C1=0). Thus a connection change, i.e., breaking an existing connection and then making a new one, can be accomplished in one RapidConfigure cycle. Tables in Appendix A provide information on determining the word locations of real SRAM cells. Refer to I-Cube's application notes for further details of using RapidConfigure.

Attempting to alter the contents of the SRAM cells responsible for connections to the I/O Ports used for the RapidConfigure Interface will result in unpredictable results.

Operation	Control Bus {P/$\overline{S}$, C[1:0]}	Row Address RA[m-1:0]	Column Address CA[m-1:0]
Break the connection between I/O Ports i & j by writing a "0" to the SRAM cell location whose Row Address is i and Column Address is j, [0 ≤ i, j ≤ r]. Other SRAM cells are unchanged, i.e., no other connections are affected.(2,3)	010	BINARY(i)	BINARY(j)
Make the connection between I/O Ports i & j by writing a "1" to the SRAM cell location whose Row Address is i and Column Address is j, [0 ≤ i, j ≤ r]. Other SRAM cell are unchanged, i.e., no other connections are affected.(2,3)	011	BINARY(i)	BINARY(j)
Break the connection between I/O Ports i & j by writing a "0" to the SRAM cell location whose Row Address is i and Column Address is j, [0 ≤ i, j ≤ r]. Clear all SRAM cells on row i; i.e., break all the connections controlled by the *real* SRAM cells belonging to row i.(2,3)	000	BINARY(i)	BINARY(j)
Make the connection between I/O Ports i & j by writing a "1" to the SRAM cell location whose Row Address is i and Column Address is j, [0 ≤ i, j ≤ r]. Clear all SRAM cells on row i; i.e., break all the connections controlled by the *real* SRAM cells belonging to row i.(2,3)	001	BINARY(i)	BINARY(j)

Table 4. Changing Switch Matrix Connections Using RapidConfigure

Notes:

(1) Binary (j) is the m-bit binary equivalent value of i. Right most bit is LSB. m equals Row/Column Address width. "i" and "j" refer to the I/O Port number on the device die.

(2) "r" is the I/O Port number on the die corresponding the highest available signal I/O Port.

(3) Assumes the real SRAM cell controlling the connection has Row Address=Binary(j)

1.4.2 I/O Port Configuration

Configuring I/O Ports using the RapidConfigure interface involves two steps. During the first step the 50-bit I/O Port Configuration Holding Register, consisting of seven 8-bit segments, is loaded with the configuration data. The loading is accomplished one 8-bit segment at a time, and may take up to 7 RapidConfigure cycles to load this register. In the second step, the data in the I/O Port Configuration Holding Register is completely transferred to the individual I/O Ports in a single RapidConnect cycle. A single I/O Port, or a group of 2, 4, 8 or 16 *contiguous* I/O Ports with a starting address of modulo 2, 4, 8 or 16 respectively, (and requiring the same configuration) can be configured in a single RapidConfigure cycle during this step.

When using RapidConfigure for configuring I/O Ports, the Control bus, {P/$\overline{S}$ = 1, C[1:0]} specifies the type of operation; and the Row and Column Addresses provide the information about the I/O Port, or the group of ports to be configured. P/$\overline{S}$ is set to 1 when configuring I/O Ports using RapidConfigure. Refer to Table 5 for details. The I/O Port information specified in the Row and Column address values applies to the I/O pad location on the *die*. When using the RapidConfigure interface for configuring bondout versions such as the IQX240B and IQX128B proper translation for I/O Port number on the package to the corresponding I/O Port number on the die must first be made. Refer to Appendix A for the mapping.

I/O Ports used for the RapidConfigure interface P/$\overline{S}$, C[1:0], RA, CA, $\overline{WE}$ and $\overline{STROBE}$, cannot be configured using the RapidConfigure interface. Combinations not listed in Table 5 may result in unpredictable results and should be avoided.

Operation	Control Bus {P/$\overline{S}$, C[1:0]}	IQX320, IQX240B		IQX160		IQX128B	
		Row Add. RA[8:0]	Col. Add. CA[8:0]	Row Add. RA[7:0]	Col. Add. CA[7:0]	Row Add. RA[6:0]	Col. Add. CA[6:0]
Load Configuration Register (1)	110	000000sss	0ddddddd	0000sssd	0ddddddd	000sssd	ddddddd
Configure Port i [0 ≤ i ≤ r] (2,3)	111	ppppppppp	000000001	pppppppp	00000001	ppppppp	0000001
Configure 2 I/O Port Group	111	pppppppp0	000000011	ppppppp0	00000011	pppppp0	0000011
Configure 4 I/O Port Group	111	ppppppp00	000000111	pppppp00	00000111	ppppp00	0000111
Configure 8 I/O Port Group	111	pppppp000	000001111	ppppp000	00001111	pppp000	0001111
Configure 16 I/O Port Group	111	ppppp0000	000011111	pppp0000	00011111	ppp0000	0011111

Table 5. Configuring I/O Ports Using RapidConfigure Interface

Notes:

(1) "sss" is the 8-bit segment in the 50-bit I/O Port Configuration Holding Register and ddddddd is the 8-bit data to be loaded. Right most bits are LSBs.

(2) "ppppp...." is the I/O Port or I/O Port Group number to be configured. This vector is 9-bits long or less, depending on the device and size of the I/O Port Group. The I/O Port Group is a contiguous group of I/O Ports with the lowest I/O Port number being (ppppp....) multiplied by (Number of Ports in the Group).

(3) "r" is the I/O Port number on the die corresponding to the highest I/O Port number on the package that can be configured using RapidConfigure.

1.4.3 I/O Port Configuration Holding Register

I/O Port Configuration Holding Register is used to hold the data that is to be loaded into the I/O Port Configuration Register. This 50-bit holding register consists of six 8-bit segments and one 2-bit segment, and is loaded one segment at a time using the RapidConfigure interface.

Using the RapidConfigure interface, the holding register is first loaded with 50 bits of data that defines the I/O Port function. The data is then transferred into the I/O Port Configuration Register(s), also using the RapidConfigure interface. Depending on the current contents of the holding register segments, it may take 7 RapidConfigure cycles or less to load the holding register. The holding register contains unknown values when the device is reset.

Table 6 describes the I/O Port programming bits and shows their location in the I/O Port Configuration Holding Register. Table 7 shows the bit values for the various I/O Port configurations.

Name	Seg#	Bit#	Group Function	Reset Value	Description
IES0	0	0	Input Group	1	Input Enable (IE) Source Bit 0 (LSB).
IES1		1		1	Input Enable (IE) Source Bit 1.
IES2		2		1	Input Enable (IE) Source Bit 2.
IES3		3		1	Input Enable (IE) Source Bit 3 (MSB).
INV_IE		4		1	Invert Polarity for Input Enable; Default is Active High.
IN		5		1	Input Port Mode.
A0		6		0	Force Array Side Low.
A1		7		0	Force Array Side High.
OES0	1	0	Output Group	1	Output Enable ($\overline{OE}$) Source Bit 0 (LSB).
OES1		1		1	Output Enable ($\overline{OE}$) Source Bit 1.
OES2		2		1	Output Enable ($\overline{OE}$) Source Bit 2.
OES3		3		1	Output Enable ($\overline{OE}$) Source Bit 3 (MSB).
INV_OE		4		1	Invert Polarity for Output Enable, Default is Active Low.
OP		5		0	Output Port Mode.
F0		6		0	Force Pin Side Low.
F1		7		0	Force Pin Side High.
CLKS0	2	0	Clock Source, Register, and Latch Group	1	Clock (CLK) Source Bit 0 (LSB).
CLKS1		1		1	Clock (CLK) Source Bit 1.
CLKS2		2		1	Clock (CLK) Source Bit 2.
CLKS3		3		1	Clock (CLK) Source Bit 3 (MSB).
LO		4		0	Latched Output Mode.
LI		5		0	Latched Input Mode.
RO		6		0	Registered Output Mode.
RI		7		0	Registered Input Mode.

Table 6. I/O Port Configuration Bits

Name	Seg#	Bit#	Group Function	Reset Value	Description
CKES0	3	0	Clock Enable Group	1	Clock Enable (CKE) Source Bit 0 (LSB).
CKES1		1		1	Clock Enable (CKE) Source Bit 1.
CKES2		2		1	Clock Enable (CKE) Source Bit 2.
CKES3		3		1	Clock Enable (CKE) Source Bit 3 (MSB).
INV_CKE		4		1	Invert Polarity for Clock Enable; Default is enabled when high for Register and transparent when High for Latch.
INV_CLK		5		0	Invert Polarity for Clock; Default is Rising Edge Triggered for Register and Transparent when High for Latch.
INV_PI		6		0	Invert Input Data in Registered Input (RI) mode.
reserved		7		0	Reserved for internal use. Must be set to default value.
K0	4	0	Key Control and Pipeline Delay Group	0	Key Tag Bit 0 (LSB).
K1		1		0	Key Tag Bit 1.
K2		2		0	Key Tag Bit 2.
K3		3		0	Key Tag Bit 3.
K4		4		0	Key Tag Bit 4 (MSB).
DELAY0		5		0	Input Pipeline Delay Bit 0 (LSB).
DELAY1		6		0	Input Pipeline Delay Bit 1.
DELAY2		7		0	Input Pipeline Delay Bit 2 (MSB).
BR	5	0	Misc. Group	0	Bus Repeater Mode.
IAS		1		1	Array Side Trickle Current.
IPS		2		1	Pin Side Trickle Current.
PU_WK		3		0	Weak Static Pull Up Current.
PU_SG		4		0	Strong Static Pull Up Current.
NB		5		0	Non-Buffered Mode.
reserved		6		1	Reserved for internal use. Must be set to default value.
reserved		7		1	Reserved for internal use. Must be set to default value.
reserved	6	0	Test Group	0	Reserved for internal use. Must be set to default value.
reserved		1		0	Reserved for internal use. Must be set to default value.

Table 6. I/O Port Configuration Bits *(Continued)*

1.4.4 I/O Port Configuration Register Contents

I/O Mode	Mnemonic	Seg 6 Bit 76543210	Seg 5 Bit 76543210	Seg 4 Bit 76543210	Seg 3 Bit 76543210	Seg 2 Bit 76543210	Seg 1 Bit 76543210	Seg 0 Bit 76543210
		. . . . .	. . WB PU_SQ PU_WK IPS IAS BR	DELAY2 DELAY1 DELAY0 K4 K3 K2 K1 K0	INV_PI INV_CLK INV_CKE CKES3 CKES2 CKES1 CKES0	RI RO LI LO CLKS3 CLKS2 CLKS1 CLKS0	F1 F0 OP INV_OE OES3 OES2 OES1 OES0	A1 A0 IN INV_IE IES3 IES2 IES1 IES0
Value After Reset		00000000	11000110	00000000	00011111	00001111	00011111	00111111
Input	IN	00000000	11000110	00000000	00011111	00001111	00011111	00111111
Input w/ Tristate		00000000	11000110	000*****	00011111	00001111	00011111	001*****
Latched Input	LI	00000000	11000110	000*****	00******	0010****	00011111	00111111
Latched Input w/ Tristate		00000000	11000110	000*****	00******	0010****	00011111	001*****
Registered Input	RI	00000000	11000110	********	0*******	1000****	00011111	00011111
Registered Input w/ Tristate		00000000	11000110	********	0*******	1000****	00011111	00001111
Output	OP	00000000	11000110	00000000	00011111	00001111	00101111	000*****
Output w/ Tristate		00000000	11000110	000*****	00011111	00001111	001*****	00001111
Latched Output	LO	00000000	11000110	000*****	00******	0001****	00101111	00001111
Latched Output w/ Tristate		00000000	11000110	000*****	00******	0001****	001*****	00001111
Registered Output	RO	00000000	11000110	00000000	00******	0100****	00001111	00001111
Registered Output w/ Tristate		00000000	11000110	000*****	00******	0100****	000*****	00001111
Bidirectional Transceiver	BT	00000000	11000110	00000000	00111111	00001111	001*****	001*****
Bidirectional Transceiver w/ Latched Input	BT&LI	00000000	11000110	000*****	00******	0010****	001*****	001*****
Bidirectional Transceiver w/ Registered Input	BT&RI	00000000	11000110	000*****	00******	1000****	001*****	000*****
Bidirectional Transceiver w/ Latched Output	BT&LO	00000000	11000110	000*****	00******	0001****	001*****	001*****
Bidirectional Transceiver w/ Registered Output	BT&RO	00000000	11000110	000*****	00******	0100****	000*****	001*****
Pin Force 0	F0	00000000	11000110	00000000	00011111	00001111	01001111	00001111
Pin Force 1	F1	00000000	11000110	00000000	00011111	00001111	10001111	00001111
Array Force 0	A0	00000000	11000110	00000000	00011111	00001111	00011111	01011111
Array Force 1	A1	00000000	11000110	00000000	00011111	00001111	00011111	10011111
Bus Repeater	BR	00000000	110**111	00000000	00011111	00001111	00101111	00111111
No Connect	NC	00000000	11000110	00000000	00011111	00001111	00011111	00001111

Table 7. I/O Configuration Register Contents

Note:

* User defined value

Each programmable I/O Port on the IQX device contains a 50-bit Configuration Register. The function of an I/O Port is determined by the contents of its configuration register. Table 7 shows the contents for the different I/O functions. Combinations that are not listed are illegal and may result in improper operation or damage to the device.

The bits in Table 7 indicated by a "*" refer to the values and polarity of the various control sources and must be filled in correctly based on the user selection of the control sources.

1.4.5 Reset Commands

The RapidConfigure interface can also be used to quickly clear the Switch Matrix and reset the I/O Ports to their default state. Refer to the table below for details. When RapidConfigure is used for resetting the I/O Ports the contents of the configuration holding register are set to the default state shown in Table 8, however the contents of the Mode Control Register and the state of the JTAG controller are not affected.

Operation	Control Bus (P/S, C[1:0])	IQX320, IQX240B		IQX160		IQX128B	
		Row Add. RA[8:0]	Col. Add. CA [8:0]	Row Add. RA[7:0]	Col. Add. CA[7:0]	Row Add. RA[6:0]	Col. Add. CA[6:0]
Clear All Switch Matrix SRAM Cells (Break Connections)	111	000000000	000100000	00000000	00100000	0000000	0100000
Clear All Switch Matrix SRAM Cells (Break Connections) and Set All I/O Ports to Power-on Default Function [Input (IN)]	111	000000000	001100000	00000000	01100000	0000000	1100000

Table 8. RapidConfigure Reset Commands

1.5 JTAG-based Configuration Controller

In the IQX devices, the I/O attributes and Switch Matrix connections can be programmed using the JTAG serial bus. Additionally, the RapidConfigure Interface, used for quickly changing I/O Port Configurations and Switch Matrix connections, can be enabled or disabled using the JTAG serial bus.

The JTAG-based serial mode is always available for configuration regardless of whether the RapidConfigure mode is enabled or disabled. However proper care must be taken when switching between JTAG and RapidConfigure for configuring the devices. The user must ensure that the RapidConfigure mode is first disabled by using JTAG serial mode to set the RC bit to zero in the Mode Control Register before attempting to change Switch Matrix connections or I/O Port configuration through JTAG.

In most cases, the user does not need to know the details of the JTAG protocol. The I-Cube supplied software will automatically generate the necessary bit stream from a higher-level textual description of the required configuration.

1.5.1 JTAG Interface

The JTAG interface is a serial interface and uses five pins: Test Data In (TDI), Test Data Out (TDO), Test Clock (TCK), Test Mode Select (TMS) and Test Reset (TRST*). TCK is used to clock data in and out of TDI and TDO. TMS, in conjunction with TDI implements a state machine that controls the various operations of the JTAG protocol. Data on the TDI and TMS pins is clocked into the IQX device on the rising edge of the TCK signal, while the valid data appears on the TDO pin after the falling edge of TCK. On the IQX devices, TRST* is used to reset both the device and the JTAG controller.

1.5.2 I/O Port Configuration

I/O Port configuration is accomplished by loading the appropriate bit stream into the programming registers present at each I/O Port. The JTAG serial bus is used to load configuration data into the I/O Port programming registers, one I/O Port at a time.

1.5.3 Switch Matrix Configuration

The contents of the SRAM cells controlling Switch Matrix connections can be modified using the JTAG. This is accomplished by loading the configuration data, one word at a time into the SRAM cells in the Switch Matrix.

1.5.4 Mode Control Register Configuration

The IQX device contains a Mode Control Register. Some bits in the register are used to store user flags such as RapidConfigure Enable, and certain non-user flags required for proper functioning of the device. The contents of this register can be changed using the JTAG interface. Refer to Table 10 for details.

2.0 MISCELLANEOUS DETAILS

2.1 Device Reset

To ensure proper operation, the device reset pin, TRST* must be held low during power up. The reset pulse must be at least 200 ns long. The IQX device is ready for configuration as soon as it comes out of reset. The recommended reset circuitry is shown in Figure 8, using an external supervisor device.

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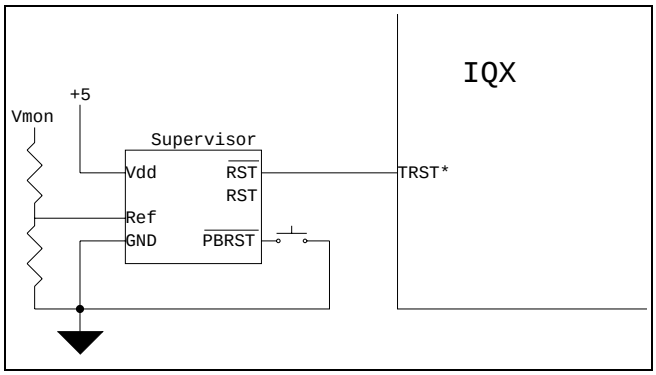

Figure 8. Reset Circuit

It should be noted that the TRST* pin must not be driven by any devices which cannot guarantee a low signal during power-up. Improper devices are those whose pins are either high or tri-stated during power-up. Examples of such devices are SRAM-based FPGAs.

When the device is in operation, different functional blocks can be reset using one of following methods. Each method performs a slightly different action as shown in Table 9.

In any of the reset methods the edge and level-sensitive flip-flops in the I/O Port buffers are not cleared and will have unknown output values.

Reset Method	Switch Matrix	I/O Ports	I/O Config. Holding Register	JTAG State Machine	RapidConfigure Interface
Pulsing TRST* low	Cleared	Set to Input (IN)	Set to Input (IN)	Reset	Enabled if RCE pin = 1
Shifting in the “Device Reset” instruction using JTAG	Cleared	Set to Input (IN)	Set to Input (IN)	Unchanged	Enabled if RCE pin = 1
Applying “I/O Port and Switch Matrix Reset” instruction using RapidConfigure interface	Cleared	Set to Input (IN)	Set to Input (IN)	Unchanged	Stays Enabled
Applying “Switch Matrix Reset” instruction using RapidConfigure interface	Cleared	Unchanged	Unchanged	Unchanged	Stays Enabled

Table 9. Device Reset

2.2 Mixed Voltage Operation

There are multiple sources for power on the IQX device. The first one called V_{DD} is a 5V source and is used to power the device core, including the Switch Matrix SRAM cells, I/O Port logic (excluding the I/O buffer driver), I/O control logic, JTAG logic and other circuitry. The I/O buffer drivers are powered by a different source called V_{DD}.PAD. The number of V_{DD}.PAD sources depends on the device. Table 13 shows the number of V_{DD}.PAD sources and the I/O Ports controlled by them. The V_{DD}.PAD pins can be connected to either a 5V or 3V supply. This makes it easy to interface IQX device to 5V and/or 3V logic levels.

2.3 Power Pin V_{DD}.X

The IQX devices contain a pin marked V_{DD}.X. The devices contain an on-chip charge pump. In order for the charge pump to operate correctly, it is required that the $V_{DD.X}$ pin be left floating and completely unconnected. The charge pump should also be left in its default “on’ setting. This is controlled by bit #6 (C_PUMP) of the mode control register.

2.4 Mode Control Register

The IQX device contains a 16-bit Mode Control Register. It stores the RapidConfigure Enable and certain other non-user flags which must be set correctly for the proper functioning of the device. Table 10 shows the bit assignment and their function.

A special JTAG instruction is used to write to the Mode Control Register. When this register is written using JTAG the least significant bit (Bit 0) is shifted in first.

Bit #	Name	Default	Description
0	KCNT	0	Key Counter Enable. When set, uses the internal 5-bit counter to provide Key Address
1	RM	*	Used to enable IOB configuration through RapidConfigure interface. Default value equals the RCE pin value on Reset.
2	RC	*	Enables or disables RapidConfigure mode. Default value equals the RCE pin value on Reset.
3	IOB_PU1	1	IOB Pull Up 10k Ref
4	BRO_PW1	1	BR external one-shot Pulse Width 10k Ref
5	BRI_PW1	1	BR internal one-shot Pulse Width 10k Ref
6	C_PUMP	1	Charge Pump Enable Bit
7	IOB_PU2	0	IOB Pull Up 20k Ref
8	BRO_PW2	0	BR external one-shot Pulse Width 20k Ref
9	BRI_PW2	0	BR internal one-shot Pulse Width 20k Ref
10	INTERNAL	0	For internal use. Should not be changed by the user.
11	KVAL0	0	Terminal count value bit 0 (LSB) when internal counter is used as Key Address
12	KVAL1	0	Terminal count value bit 1 when internal counter is used as Key Address
13	KVAL2	0	Terminal count value bit 2 when internal counter is used as Key Address
14	KVAL3	0	Terminal count value bit 3 when internal counter is used as Key Address
15	KVAL4	0	Terminal count value bit 4 (MSB) when internal counter is used as Key Address

Table 10. Mode Control Register Bit Assignment

3.0 In System Configuration Using JTAG-based Configuration Controller

The JTAG-based configuration mode allows the user to initialize the device, configure the I/O Ports, establish connections through the Switch Matrix and set the contents of the Mode Control Register.

Configuring the device using JTAG involves two steps. In the first step the user generates the bit stream. Two different software options - off-line and embedded bit stream generation - are available to accomplish this task. The choice depends on the target application. The second step is the actual downloading of the bit stream into the device. The downloading circuitry can take on different forms, depending on the target application.

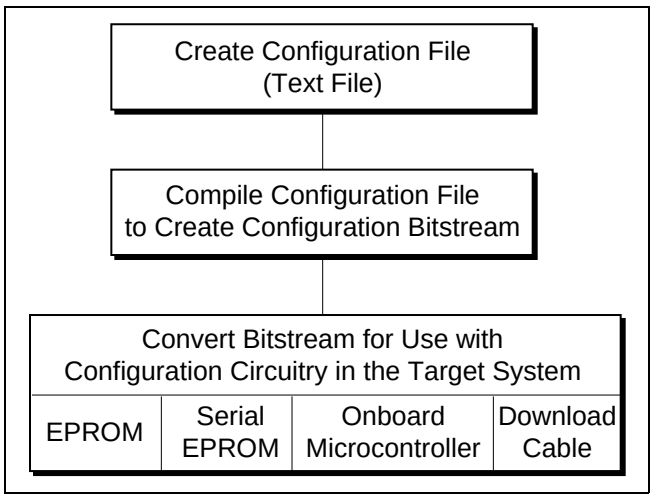

Figure 9. Off-line Bit Stream Generation

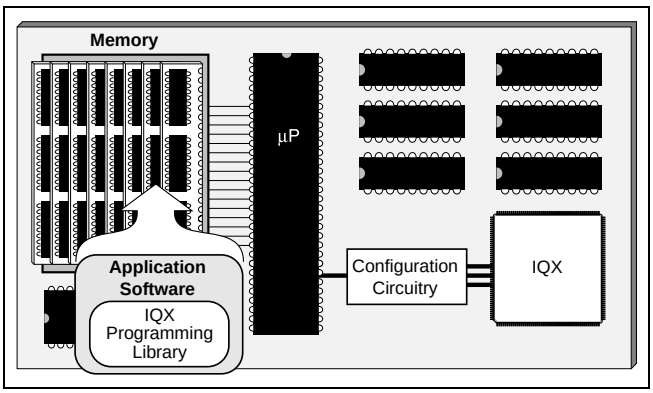

Figure 10. Embedded Bit Stream Generation

3.1 Bit Stream Generation

The configuration bit stream can be generated off-line or in-system by an embedded CPU using one of the following methods:

- By using I-Cube Development System Software product IDS100.
- By user written code based on the information provided in the "IQX Family Register Programming Users Reference."

If the bit stream is generated off-line then, depending on the application, it is either stored in non-volatile memory or directly downloaded from a host processor such as a PC connected to the target hardware.

The software used for off-line generation accepts a text file describing the desired configuration - connections between different I/O Ports, functional attributes of each I/O Port, and settings of certain user flags - and generates a file containing the bit stream.

3.2 Bit Stream Downloading

The bit stream can be downloaded into the IQX device using several different hardware schemes. The choice depends on the end application. All these schemes use the standard JTAG protocol and timing. As per the JTAG protocol, the clock signal (TCK) must be supplied externally.

If the target hardware is controlled by a computer such as a PC, the parallel port on the computer can be used to download the bit stream. I-Cube provides a software utility to perform the downloading. Under this scheme, the necessary data for TDI and TMS pins as well as the (software generated) TCK clock signal are sent over the parallel port.

An on-board byte-wide EPROM or E^2PROM, or a serial E^2PROM can be used to store the bit stream. Using minimal external logic, the bit stream stored in one of these devices can be downloaded into the IQX device(s) over the TDI and TMS pins, with the TCK pin used for synchronization. The clock signal for the TCK pin is generated by the external logic.

If the target system has an on-board microcontroller, the bit stream data can be read from memory and downloaded into the IQX device(s) using 3 I/O pins on the microcontroller to generate the required TDI, TMS and TCK signals. For real-time applications, the microcontroller/microprocessor can *generate* the bit stream (using the I-Cube supplied software examples or user written code) and then download it into the IQX device in a single operation.

The actual time required to download the configuration bit stream and program a IQX device depends on the device(s) used, the user's specific configuration pattern, and JTAG clock frequency. Table 11 shows the number of JTAG cycles and configuration time required for some typical operations. The size of the memory (number of bytes) required is two (one each for TDI and TMS) times the number of JTAG cycles divided by eight.

3.3 Configuring Multiple IQX Devices

The JTAG-based controller allows a single device or multiple IQX devices connected in a chain to be configured in a single operation. For multiple device configuration, the pins are connected as shown in Figure 11.

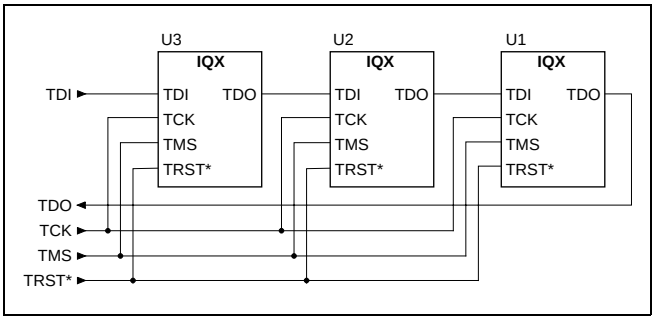

Figure 11. Configuring Multiple IQX Devices

During the initial configuration sequence, the internal controllers on all IQX devices are first brought to their reset state by pulsing the TRST* reset pin low. This is followed by the actual configuration bit stream, which is downloaded into the IQX devices over the TDI and TMS pins.

Operation	IQX320			IQX240B			IQX160			IQX128B		
	JTAG Cycles	Config. Time	Bitstream Size	JTAG Cycles	Config. Time	Bitstream Size	JTAG Cycles	Config. Time	Bitstream Size	JTAG Cycles	Config. Time	Bitstream Size
JTAG Reset Sequence (TMS = "11111")	5	500 ns	10 bits	5	500 ns	10 bits	5	500 ns	10 bits	5	500 ns	10 bits
Enable or Disable Rapid Configure	42	4.2 µs	84 bits	42	4.2 µs	84 bits	42	4.2 µs	84 bits	42	4.2 µs	84 bits
Change IOB attributes of ONE I/O Port	76	7.6 µs	152 bits	76	7.6 µs	152 bits	76	7.6 µs	152 bits	76	7.6 µs	152 bits
Change IOB attributes of ALL I/O Ports	24 K	2.4 ms	6 KB	18 K	1.8 ms	4.5 KB	12 K	1.2 ms	4 KB	10 K	1.0 ms	2.5 KB
Reset JTAG Controller + Reset ALL I/O Ports + Clear ALL SRAM cells	32	3.2 µs	64 bits	32	3.2 µs	64 bits	32	3.2 µs	64 bits	32	3.2 µs	64 bits
Connect or disconnect two I/O Ports	346	34.6 µs	692 bits	346	34.6 µs	692 bits	186	18.6 µs	372 bits	186	18.6 µs	372 bits
Configure Entire Switch Matrix	110 K	11.0 ms	27.5 KB	84 K	8.4 ms	21 KB	30 K	3.0 ms	7.5 KB	24 K	2.4 ms	6 KB
Completely Configure the Device (All I/O and All Switch Matrix Connections)	134K	13.4 ms	34 KB	102 K	10.02 ms	26 KB	42 K	4.2 ms	11 KB	34 K	3.4 ms	9 KB

Table 11. Number of JTAG Cycles and Configuration Time (using a 10 MHz JTAG Clock)

4.0 PIN SUMMARY

IQX320	IQX240B	IQX160	IQX128B	DIR	Description
P000 - P259, P262, P264, P266, P274, P276, P278, P280, P282, P284, P286, P288, P290, P292, P294, P305	P000 - P193, P225	P000 - P103, P107, P113, P118, P119, P123, P124, P129, P130, P135, P136	P000 - P083	I/O	**Dedicated I/O Ports**
P260, P261, P263, P265, P267	P194, P195, P196, P197, P198	P104, P105, P106, P108, P109	P84 -P88	I/O	**Shared I/O Ports** I/O Ports shared with General Tristate Control GT12 - GT8, used for Input Enable (IE) and Output Enable ($\overline{OE}$) Signals.
P268 - P272	P199 - P203	P110, P111, P112, P114, P115	P89 -P93	I/O	**Shared I/O Ports** I/O Ports shared with General Clock Control GC12 - GC8, used for Clock (CLK) and Clock Enable (CKE) Signals.
P273, P275, P277, P279, P281	P204 - P208	P116, P117, P120, P121, P122	P94 -P98	I/O	**Shared I/O Ports** I/O Ports shared with Key Control K4 - K0, used for generating Clock (CLK), Clock Enable (CKE), Input Enable (IE) and Output Enable ($\overline{OE}$) signals.
P283, P285, P287, P289	P209-P212	P125-P128, P138, P137	P99-P102, P108, P107	I/O	**Shared I/O Ports** I/O Ports shared with General Clock Control GC7-GC4 for IQX320 and IQX240B and GC7-GC2 for remaining devices, used for Clock (CLK) and Clock Enable (CKE) Signals.
P291, P293, P295	P213 - P215	P131 - P134	P103 - P106	I/O	**Shared I/O Ports** I/O Ports shared with General Tristate Control GT7 - GT5 for IQX320 and IQX240B and GT7 - GT4 for remaining devices, used for Input Enable (IE) and Output Enable ($\overline{OE}$) Signals.
GT4 - GT0	GT4 - GT0	GT3 - GT0	GT3 - GT0	I	**(Dedicated) General Tristate Control Pins** Used for Input Enable (IE) and Output Enable ($\overline{OE}$) Signals.
GC3 - GC0	GC3 - GC0	GC1 - GC0	GC1 - GC0	I	**(Dedicated) General Clock Control Pins** Used for Clock (CLK) and Clock Enable (CKE) signals.
P296 - P304 CA0 - CA8	P216 - P224 CA0 - CA8	P140 - P147 CA0 - CA7	P110 - P116 CA0 - CA6	I/O	**Shared I/O Ports** I/O Ports shared with Column Address (CA) Bus
P306 - P314 RA0 - RA8	P226 - P234 RA0 - RA8	P148 - P155 RA0 - RA7	P117 - P123 RA0 - RA6	I/O	**Shared I/O Ports** I/O Ports shared with Row Address (RA) Bus
P315 - P317	P235 - P237	P139, P156, P157	P109, P124, P125	I/O	**Shared I/O Ports** I/O Ports shared with P/$\overline{S}$, C0 AND C1
P318, P319	P238, P239	P158, P159	P126, P127	I/O	**Shared I/O Ports** RapidConfigure Write Enable ($\overline{WE}$) and Write Strobe ($\overline{STROBE}$)
TRST*	TRST*	TRST*	TRST*	I	**Hardware Reset** Device Reset
TDI, TMS, TCK, TDO	TDI, TMS, TCK, TDO	TDI, TMS, TCK, TDO	TDI, TMS, TCK, TDO	I I O	**JTAG Pins** For downloading the serial configuration bitstream
RCE	RCE	RCE	RCE	I	**RapidConfigure Enable Pin** For Enabling RapidConfigure interface after reset
V_{DD}.PAD1 V_{DD}.PAD2 V_{DD}.PAD3 V_{DD}.PAD4	V_{DD}.PAD1 V_{DD}.PAD2 V_{DD}.PAD3 V_{DD}.PAD4	V_{DD}.PAD1 V_{DD}.PAD2	V_{DD}.PAD1 V_{DD}.PAD2	P P P P	**Power & Ground Pins** Power Pins for Group 1 I/O Buffer Drivers. Power Pins for Group 2 I/O Buffer Drivers. Power Pins for Group 3 I/O Buffer Drivers. Power Pins for Group 4 I/O Buffer Drivers.

Table 12. IQX Pin Summary

IQX320	IQX240B	IQX160	IQX128B	DIR	Description
V_{DD} V_{DD}.X V_{SS}	V_{DD} V_{DD}.X V_{SS}	V_{DD} V_{DD}.X V_{SS}	V_{DD} V_{DD}.X V_{SS}	P P P	Power Pins for on-chip circuitry other than I/O Buffer Drivers. Supply for Switch Matrix. Ground Pins.

Table 12. IQX Pin Summary *(Continued)*

Supply Voltage	Pins Powered by Supply Voltage			
	IQX320	IQX240B	IQX160	IQX128B
V_{DD}	TDI,TMS,TCK,TRST*, GC0-GC3, GT0-GT4	TDI,TMS,TCK,TRST*, GC0-GC3, GT0-GT4	TDI,TMS,TCK, TDO, TRST*, GC0, GC1, GT0-GT3	TDI,TMS,TCK,TDO,TRST*, GC0, GC1, GT0-GT3
V_{DD}.PAD1	P000:P079, TDO	P000:P059, TDO	P000:P079	P000:P063
V_{DD}.PAD2	P080:P159	P060:P119	P080:P159	P064:P127
V_{DD}.PAD3	P160:P239	P120:P179		
V_{DD}.PAD4	P240:P319	P180:P239		

Table 13. Supply Voltage Source

5.0 ELECTRICAL SPECIFICATIONS

5.1 Absolute Maximum Ratings (1)

Symbol	Parameter	Limits	Units
V_{DD}	Supply Voltage to Ground	-0.3 to +7.0	V
V_{DD}.PAD	Supply Voltage for I/O Buffer Driver	-0.3 to +7.0	V
V_{IN} (2)	Input Voltage	-0.3 to (V_{DD}.PAD + 0.3)	V
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 to +150	°C
I_{OS}	Current per Port Pin	± 100	mA

Table 14. Absolute Maximum Ratings

5.2 Recommended Operating Conditions

Symbol	Parameter	Limits	Units
V_{DD}	Supply Voltage to Ground	4.75 to 5.25	V
V_{DD}.PAD (4)	Supply Voltage for I/O Buffer Driver	4.75 to 5.25 2.97 to 3.63	V
T_A	Operating Temperature	0 to 70	°C

Table 15. Recommended Operating Conditions

5.3 Capacitance (3)

Symbol	Parameter	Min	Max	Units
C_{IN}	Input Capacitance (JTAG pins)	-	8	pF
C_{OUT}	Output Capacitance (TDO pin)	-	8	pF
C_{PORT}	I/O Signal Port	-	10	pF
C_{CNTL}	Dedicated General Clock and General Tristate Pin Capacitance	-	10	pF

Table 16. Capacitance

Notes:

(1) Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

(2) A maximum overshoot and undershoot of 2V for a maximum duration of 20 ns is acceptable.

(3) Capacitance measured at 25°C. Sample-tested only.

(4) V_{DD}.PAD1, V_{DD}.PAD2, V_{DD}.PAD3 and V_{DD}.PAD4 can operate at different voltages from each other.

5.4 DC Electrical Specifications

(T_A = 0°C to 70°C, V_{DD} = 5V±5%; V_{DD}.PAD = 5V±5%, or V_{DD}.PAD = 3.3V±10%)

Symbol	Parameter	Conditions	IQX320, IQX240B		IQX160, IQX128B		Unit
			Min	Max	Min	Max	
V_{IH}	High-Level Input Voltage		2.0	V_{DD} + 0.3	2.0	V_{DD} + 0.3	V
V_{IL}	Low-Level Input Voltage		-0.3	0.8	-0.3	0.8	V
V_{OH}	High-Level Output Voltage	V_{DD} = Min, V_{DD}.PAD = 4.75V I_{OH} = - 8 mA	2.4	-	2.4	-	V
	High-Level Output Voltage	V_{DD} = Min, V_{DD}.PAD = 2.97V I_{OH} = - 4mA	2.4	-	2.4	-	V
V_{OL}	Low-Level Output Voltage	V_{DD} = Min, V_{DD}.PAD = 4.75V I_{OL} = 12 mA	-	0.4	-	0.4	V
	Low-Level Output Voltage	V_{DD} = Min, V_{DD}.PAD = 2.97V I_{OL} = 12 mA	-	0.4	-	0.4	V
$\|I_{IH}$"|" $\|I_{IL}\|$	Input Leakage Current for I/O ports	V_{DD} = Max, 0 ≤ V_{IN} ≤ V_{DD}.PAD	-	5	-	5	µA
I_{PT}	I/O Port Trickling Current(1)	V_{DD} = Max, 0 ≤ V_{IN} ≤ V_{DD}.PAD	-	-25	-	-25	µA
$\|I_{OZ}\|$	Tristate Output Off-State Current	V_{DD} = Max, 0 ≤ V_{IN} ≤ V_{DD}.PAD	-	5	-	5	µA
I_{PU-WK}	Programmed-Weak Additional Pull-Up Current	V_{DD} = V_{DD}.PAD = 4.75V, V_O = GND	2.5	4.0	2.0	4.0	mA
I_{PU-SG}	Programmed-Strong Additional Pull-Up Current	V_{DD} = V_{DD}.PAD = 4.75V, V_O = GND	9	13.5	8.0	13.5	mA
I_{OS}	Short Circuit Current(1, 2)	V_{DD} = Max, V_O = GND	-60	-	-60	-	mA
I_{DDQ_CORE}	Quiescent Core Power Supply Current	V_{DD} = Max, I/O = GND, CP = On	-	85	-	85	mA
		V_{DD} = Max, I/O = GND, CP = Off	-	8	-	8	mA
I_{DDQ_PAD}	Quiescent Pad Power Supply Current	V_{DD}.PAD = 5.25V, All I/O = NC V_{DD} = Max, V_O = GND	-	80	-	80	µA
Q_{DDD_CORE}	Dynamic CorePower Supply Current	V_{DD}.PAD = 5.25V, V_{DD} = Max, No Load, @ 1.0 MHZ clock input, connect one output per input	-	0.2	-	0.1	mA/ MHz
Q_{DDD_PAD}	Dynamic Pad Power Supply Current	V_{DD}.PAD = 5.25V, V_{DD} = Max, No Load, @ 1.0 MHZ clock input, connect one output per input	-	0.1	-	0.05	mA/ MHz

Table 17. DC Electrical Specifications

Notes:

(1) These parameters are guaranteed but not tested in production.

(2) No more than one output should be tested at a time and the duration of the test should be limited to less than one second.

5.5 AC Electrical Specifications for IQX320 and IQX240B

(T_A = 0°C to 70°C, V_{DD} = 5V±5%; V_{DD}.PAD = 5V±5%, or V_{DD}.PAD = 3.3V±10%. Assume two I/O ports connected through the Switch Matrix with 35 pF external loading)

Speed Grade		-10		-12			Ref.
Symbol	Parameter	Min	Max	Min	Max	Units	Figure
f_{RIO}	Register Input/Output, Clock Frequency[1, 2]		100		80	MHz	
t_{W-RIO}	Register Input/Output, Clock Pulse Width, Low or High[1, 2]	4.5		5.5		ns	
t_{S-RIO}	Register Input/Output, Data Setup Time to CLK	2.5		3.0		ns	13
t_{H-RIO}	Register Input/Output, CLK to Data Hold Time	2.0		2.0		ns	
t_{CO-RIO}	Register Input/Output, Clock to Output Data Valid		9.5		11.5	ns	
f_{RI}	Register Input, Clock Frequency[1]		80		66	MHz	
t_{W-RI}	Register Input, Clock Pulse Width, Low or High	4.5		5.5		ns	
t_{S-RI}	Register Input, Data Setup Time to CLK	2.5		3.0		ns	14
t_{H-RI}	Register Input, CLK to Data Hold Time	2.0		2.0		ns	
t_{CO-RI}	Register Input, Clock to Output Data Valid		12.5		15.0	ns	
f_{RO}	Register Output, Clock Pulse Frequency[1]		100		80	MHz	
t_{W-RO}	Register Output, Clock Width, Low or High	4.5		5.5		ns	
t_{S-RO}	Register Output, Data Setup Time to CLK	4.5		5.0		ns	15
t_{H-RO}	Register Output, CLK to Data Hold Time	0.0		0.0		ns	
t_{CO-RO}	Register Output, Clock to Output Data Valid		9.5		11.5	ns	
t_{PHL}, t_{PLH}	One Way Signal Propagation Delay		10.0		12.5	ns	
t_{SK}	Skew Between Output Ports[1]		1.5		1.5	ns	
t_{W+}	Input Flow Through Positive Pulse Width[2]	4.5		6.0		ns	16
t_{W-}	Input Flow Through Negative Pulse Width[2]	6.5		8.0		ns	
R_{DATA}	NRZ Data Rate[1, 2]		180		150	Mb/s	
t_{PZH-IT}, t_{PZL-IT}	Input Enable (GT) to Data Valid		12.0		13.0	ns	17
t_{PZH-OT}, t_{PZL-OT}	Output Enable (GT) to Data Valid		12.0		13.0	ns	18
t_{PHZ-OT}, t_{PLZ-OT}	Output Enable (GT) to Output at High Z[1]		8.5		10.5	ns	
t_{W-LI}	Latch Input, Latch Enable (GC) Pulse Width, Low or High	4.5		5.5		ns	
t_{S-LI}	Latch Input, Data Setup Time to Latch Enable (GC) Trailing Edge	2.5		3.0		ns	
t_{H-LI}	Latch Input, Data to Latch Enable (GC) Trailing Edge Hold Time	2.0		2.0		ns	19
t_{CO-LI}	Latch Input, Latch Enable (GC) Leading Edge to Data Out Delay		15.0		17.5	ns	
t_{P-LIT}	Latch Input, Transparent Mode Propagation Delay		10.0		12.5	ns	
t_{W-LO}	Latch Output, Latch Enable (GC) Pulse Width, Low or High	4.5		5.5		ns	
t_{S-LO}	Latch Output, Data Setup Time to Latch Enable (GC) Trailing Edge	4.5		5.0		ns	
t_{H-LO}	Latch Output, Data to Latch Enable (GC) Trailing Edge Hold Time	0.0		0.0		ns	20
t_{CO-LO}	Latch Output, Latch Enable (GC) Leading Edge to Data Out Delay		25.0		27.5	ns	
t_{P-LOT}	Latch Output, Transparent Mode Propagation Delay		10.0		12.5	ns	
t_{KW-RI}	Register Input, Minimum Pulse Width of KEY as Clock Enable, Low or High	6.0			7.0	ns	
t_{KS-RI}	Register Input, Clock Enable (Key) Setup Time to CLK (GC)	3.0		3.5		ns	21
t_{KH-RI}	Register Input, CLK (GC) to Clock Enable (Key) Hold Time	2.0		2.0		ns	
t_{KCO-RI}	Register Input, Key Clock to Output Data Valid		13.0		15.5	ns	

Table 18. AC Electrical Specifications for IQX320 and IQX240B

Speed Grade		-10		-12			Ref.
Symbol	Parameter	Min	Max	Min	Max	Units	Figure
t_{KW-RO}	Register Output, Minimum Pulse Width of KEY as Clock Enable, Low or High	6.0		7.0		ns	22
t_{KS-RO}	Register Output, Clock Enable (Key) Setup Time to CLK (GC)	5.0		5.5		ns	
t_{KH-RO}	Register Output, CLK (GC) to Clock Enable (Key) Hold Time	0.0		0.0		ns	
t_{KCO-RO}	Register Output, Key Clock to Output Data Valid		7.5		9.5	ns	
$t_{KPZH-IT}$ $t_{KPZL-IT}$	Input Enable (Key) to Data Valid		11.0		13.5	ns	23
$t_{KPZH-OT}$ $t_{KPZL-OT}$	Output Enable (Key) to Data Valid		9.0		11.0	ns	24
$t_{KPHZ-OT}$ $t_{KPLZ-OT}$	Output Enable (Key) to Output at High Z(1)		9.0		11.0	ns	
t_{KW-LI}	Latch Input, Minimum Pulse Width of KEY as Latch Enable, Low or High	6.0		7.0		ns	25
t_{KS-LI}	Latch Input, Data Setup Time to Latch Enable (Key) Trailing Edge	3.0		3.5		ns	
t_{KH-LI}	Latch Input, Data to Latch Enable (Key) Trailing Edge Hold Time	2.0		2.0		ns	
t_{KCO-LI}	Latch Input, Latch Enable (Key) Leading Edge to Data Out		13.0		15.5	ns	
t_{KP-LIT}	Latch Input, Transparent Mode Propagation Delay		10.0		12.5	ns	
t_{KW-LO}	Latch Output, Minimum Pulse Width of KEY as Latch Enable, Low or High	6.0		7.0		ns	26
t_{KS-LO}	Latch Output, Data Setup Time to Latch Enable (Key) Trailing Edge	5.0		5.5		ns	
t_{KH-LO}	Latch Output, Data to Latch Enable (Key) Trailing Edge Hold Time	0.0		0.0		ns	
t_{KCO-LO}	Latch Output, Latch Enable (Key) Leading Edge to Data Out		7.5		9.5	ns	
t_{KP-LOT}	Latch Output, Transparent Mode Propagation Delay		10.0		12.5	ns	
f_{KCNT}	Key Counter, Input Clock Frequency		66		50	MHz	27
t_{WKCNT}	Key Counter Clock, Pulse Width	6.0		7.0		ns	
t_{S_KCKE}	Key Counter, Enable Setup Time to KCLK	2.5		3.5		ns	
t_{H_KCKE}	Key Counter, KCLK to Enable Hold Time	0.0		0.0		ns	
t_{S_KRST}	Key Counter, Reset Setup Time to KCLK	2.5		3.5		ns	
t_{H_KRST}	Key Counter, KCLK to Reset Hold Time	0.0		0.0		ns	
t_{KCLK_OE}	Key Counter, Clock to Output Data Valid or Output High Z		9.5		11.5	ns	
t_{KCLK_IE}	Key Counter, Clock to Input Data Valid		11.5		14.0	ns	
t_{P_KCLR}	Key Counter, Clear to Output Active / High Z Delay		11.5		13.5	ns	
t_{P_KF1F}	Key Counter, Force 0x1F to Output Active / High Z Delay		10.5		12.5	ns	
T_{RC}	RapidConfigure Strobe Period	30.0		32.5		ns	28
$t_{W+ -RC}$, $t_{W- -RC}$	RapidConfigure Strobe Pulse Width	6.0		7.0		ns	
t_{S-RC}	RapidConfigure Address and Data Setup Time to Strobe	0.0		0.0		ns	
t_{H-RC}	RapidConfigure Address and Data Hold Time to Strobe	3.0		3.0		ns	
t_{P-RC}	RapidConfigure Strobe Falling Edge to Data Valid (Make Connection)		35.0		37.5	ns	
f_{JTAG}	JTAG Clock (TCK) Frequency		10		10	MHz	29
t_{W-JTAG}	JTAG Clock (TCK) Pulse Width	20.0		20.0		ns	
t_{S-JTAG}	JTAG Setup Time	4.0		4.0		ns	
t_{H-JTAG}	JTAG Hold Time	0.0		0.0		ns	
t_{P-JTAG}	JTAG Clock to Output Data Valid	15.0		15.0		ns	

Table 18. AC Electrical Specifications for IQX320 and IQX240B *(Continued)*

Notes:

(1) These parameters are guaranteed but not tested in production.

(2) The timing parameters are specified for a configuration where an Input Port is driving one Output Port. For configurations where an Input Port is driving two or more Output Ports, the timing parameters are de-rated as shown in Section 5.7 or Table 20. These parameters are guaranteed but not tested in production.

5.6 AC Electrical Specifications for IQX160 and IQX128B

(T_A = 0°C to 70°C, V_{DD} = 5V±5%; V_{DD}.PAD = 5V±5%, or V_{DD}.PAD = 3.3V±10%. Assume two I/O Ports connected through the Switch Matrix with 35 pF external loading.)

Speed Grade		-7		-10			Ref.
Symbol	Parameter	Min	Max	Min	Max	Units	Figure
f_{RIO}	Register Input/Output, Clock Frequency[1, 2]		133		100	MHz	
t_{W-RIO}	Register Input/Output, Clock Pulse Width, Low or High[1, 2]	3.3		4.5		ns	
t_{S-RIO}	Register Input/Output, Data Setup Time to CLK	2.0		3.0		ns	13
t_{H-RIO}	Register Input/Output, CLK to Data Hold Time	0.0		0.0		ns	
t_{CO-RIO}	Register Input/Output, Clock to Output Data Valid		8.5		10.0	ns	
f_{RI}	Register Input, Clock Frequency[1]		100		80	MHz	
t_{W-RI}	Register Input, Clock Pulse Width, Low or High	3.3		4.5		ns	
t_{S-RI}	Register Input, Data Setup Time to CLK	2.0		3.0		ns	14
t_{H-RI}	Register Input, CLK to Data Hold Time	0.0		0.0		ns	
t_{CO-RI}	Register Input, Clock to Output Data Valid		12.0		15.0	ns	
f_{RO}	Register Output, Clock Pulse Frequency [1]		133		100	MHz	
t_{W-RO}	Register Output, Clock Width, Low or High	3.3		4.5		ns	
t_{S-RO}	Register Output, Data Setup Time to CLK	3.0		4.0		ns	15
t_{H-RO}	Register Output, CLK to Data Hold Time	0.0		0.0		ns	
t_{CO-RO}	Register Output, Clock to Output Data Valid		8.5		10.0	ns	
t_{PHL}, t_{PLH}	One Way Signal Propagation Delay		7.5		10.0	ns	
Δt_{BR}	Additional Delay in Bus Repeater (BR) Mode [1, 2]		0.0		0.0	ns	
t_{SK}	Skew Between Output Ports[1]		1.5		1.5	ns	
t_{W+}	Input Flow Through Positive Pulse Width[2]	3.5		4.5		ns	16
t_{W-}	Input Flow Through Negative Pulse Width[2]	4.5		5.0		ns	
R_{DATA}	NRZ Data Rate [1, 2]		200		180	Mb/s	
t_{PZH-IT}, t_{PZL-IT}	Input Enable (GT) to Data Valid		10.0		12.5	ns	17
t_{PZH-OT}, t_{PZL-OT}	Output Enable (GT) to Data Valid		9.0		10.0	ns	
t_{PHZ-OT}, t_{PLZ-OT}	Output Enable (GT) to Output at High Z [1]		7.0		8.5	ns	18
t_{W-LI}	Latch Input, Latch Enable (GC) Pulse Width, Low or High	3.3		4.5		ns	
t_{S-LI}	Latch Input, Data Setup Time to Latch Enable (GC) Trailing Edge	2.0		3.0		ns	
t_{H-LI}	Latch Input, Data to Latch Enable (GC) Trailing Edge Hold Time	4.0		4.0		ns	19
t_{CO-LI}	Latch Input, Latch Enable (GC) Leading Edge to Data Out Delay		12.0		15.0	ns	
t_{P-LIT}	Latch Input, Transparent Mode Propagation Delay		9.0		10.0	ns	
t_{W-LO}	Latch Output, Latch Enable (GC) Pulse Width, Low or High	3.3		4.5		ns	
t_{S-LO}	Latch Output, Data Setup Time to Latch Enable (GC) Trailing Edge	4.0		5.0		ns	
t_{H-LO}	Latch Output, Data to Latch Enable (GC) Trailing Edge Hold Time	0.0		0.0		ns	20
t_{CO-LO}	Latch Output, Latch Enable (GC) Leading Edge to Data Out Delay		35.0		40.0	ns	
t_{P-LOT}	Latch Output, Transparent Mode Propagation Delay		8.0		10.0	ns	
t_{KW-RI}	Register Input, Minimum Pulse Width of KEY as Clock Enable, Low or High	5.0		6.0		ns	
t_{KS-RI}	Register Input, Clock Enable (Key) Setup Time to CLK (GC)	2.5		3.0		ns	21
t_{KH-RI}	Register Input, CLK (GC) to Clock Enable (Key) Hold Time	2.0		2.0		ns	
t_{KCO-RI}	Register Input, Key Clock to Output Data Valid		10.5		13.0	ns	

Table 19. AC Electrical Specifications for IQX160 and IQX128B

Speed Grade		-7		-10			Ref.
Symbol	Parameter	Min	Max	Min	Max	Units	Figure
t_{KW-RO}	Register Output, Minimum Pulse Width of KEY as Clock Enable, Low or High	5.0		6.0		ns	22
t_{KS-RO}	Register Output, Clock Enable (Key) Setup Time to CLK (GC)	4.5		5.0		ns	
t_{KH-RO}	Register Output, CLK (GC) to Clock Enable (Key) Hold Time	0.0		0.0		ns	
t_{KCO-RO}	Register Output, Key Clock to Output Data Valid		6.5		7.5	ns	
$t_{KPZH-IT}$ $t_{KPZL-IT}$	Input Enable (Key) to Data Valid		9.0		11.0	ns	23
$t_{KPZH-OT}$ $t_{KPZL-OT}$	Output Enable (Key) to Data Valid		7.5		9.0	ns	24
$t_{KPHZ-OT}$ $t_{KPLZ-OT}$	Output Enable (Key) to Output at High Z(1)		7.5		9.0	ns	
t_{KW-LI}	Latch Input, Minimum Pulse Width of KEY as Latch Enable, Low or High	5.0		6.0		ns	25
t_{KS-LI}	Latch Input, Data Setup Time to Latch Enable (Key) Trailing Edge	2.5		3.0		ns	
t_{KH-LI}	Latch Input, Data to Latch Enable (Key) Trailing Edge Hold Time	2.0		2.0		ns	
t_{KCO-LI}	Latch Input, Latch Enable (Key) Leading Edge to Data Out		10.5		13.0	ns	
t_{KP-LIT}	Latch Input, Transparent Mode Propagation Delay		7.5		10.0	ns	
t_{KW-LO}	Latch Output, Minimum Pulse Width of KEY as Latch Enable, Low or High	5.0		6.0		ns	26
t_{KS-LO}	Latch Output, Data Setup Time to Latch Enable (Key) Trailing Edge	4.5		5.0		ns	
t_{KH-LO}	Latch Output, Data to Latch Enable (Key) Trailing Edge Hold Time	0.0		0.0		ns	
t_{KCO-LO}	Latch Output, Latch Enable (Key) Leading Edge to Data Out		6.5		7.5	ns	
t_{KP-LOT}	Latch Output, Transparent Mode Propagation Delay		7.5		10.0	ns	
f_{KCNT}	Key Counter, Input Clock Frequency		80		66	MHz	27
t_{WKCNT}	Key Counter Clock, Pulse Width	5.0		6.0		ns	
t_{S_KCKE}	Key Counter, Enable Setup Time to KCLK	2.0		2.5		ns	
t_{H_KCKE}	Key Counter, KCLK to Enable Hold Time	0.0		0.0		ns	
t_{S_KRST}	Key Counter, Reset Setup Time to KCLK	2.0		2.5		ns	
t_{H_KRST}	Key Counter, KCLK to Reset Hold Time	0.0		0.0		ns	
t_{KCLK_OE}	Key Counter, Clock to Output Data Valid or Output High Z		8.0		9.5	ns	
t_{KCLK_IE}	Key Counter, Clock to Input Data Valid		9.5		11.5	ns	
t_{P_KCLR}	Key Counter, Clear to Output Active / High Z Delay		9.5		11.5	ns	
t_{P_KF1F}	Key Counter, Force 0x1F to Output Active / High Z Delay		8.5		10.5	ns	
T_{RC}	RapidConfigure Strobe Period	15.0		17.0		ns	28
$t_{W+\ -RC}$, $t_{W-\ -RC}$	RapidConfigure Strobe Pulse Width	6.0		7.5		ns	
t_{S-RC}	RapidConfigure Address and Data Setup Time to Strobe	2.0		3.0		ns	
t_{H-RC}	RapidConfigure Address and Data Hold Time to Strobe	0.0		0.0		ns	
t_{P-RC}	RapidConfigure Strobe Falling Edge to Data Valid (Make Connection)		25.0		30.0	ns	
f_{JTAG}	JTAG Clock (TCK) Frequency		10		10	MHz	29
t_{W-JTAG}	JTAG Clock (TCK) Pulse Width	20.0		20.0		ns	
t_{S-JTAG}	JTAG Setup Time	4.0		4.0		ns	
t_{H-JTAG}	JTAG Hold Time	0.0		0.0		ns	
t_{P-JTAG}	JTAG Clock to Output Data Valid	15.0		15.0		ns	

Table 19. AC Electrical Specifications for IQX160 and IQX128B *(Continued)*

Notes:

(1) These parameters are guaranteed but not tested in production.

(2) The timing parameters are specified for a configuration where an Input Port is driving one Output Port. For configurations where an Input Port is driving two or more Output Ports, the timing parameters are de-rated as shown in Section 5.7 or Table 20. These parameters are guaranteed but not tested in production.

5.7 Parameter De-rating For One-to-Many Connections

Symbol	Parameter	IQX320		IQX240B		IQX160		IQX128B		Units
		Min	Max	Min	Max	Min	Max	Min	Max	
CN_{MAX}	Maximum Number of Connections Per Input	-	32	-	32	-	32	-	32	
Δt_{PD}	Increase in t_{PD} for Every Additional Output Port Connected to an Input Port	-	0.35	-	0.35	-	0.25	-	0.25	ns
Δt_W	Increase in tw+ and tw- for Every Additional Output Port Connected to an Input Port	-	200	-	200	-	160	-	160	ps
Δf	Decrease in Maximum Operating Frequency Every Additional Output Port Connected to an Input Port	-	1	-	1	-	0.75	-	0.75	MHz

Table 20. Parameter De-rating For One-to-Many Connections

5.8 Test Circuit and Timing Diagrams

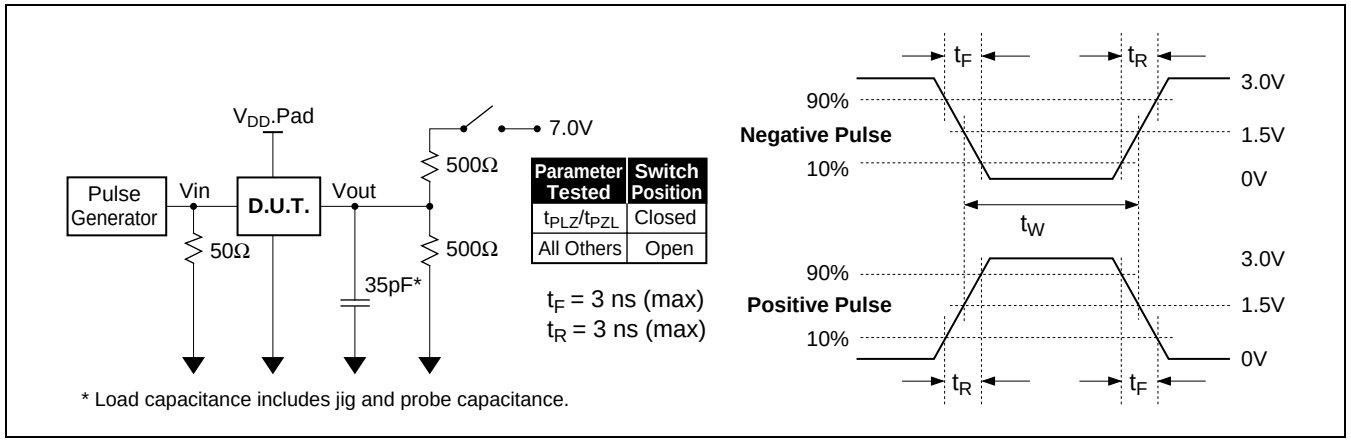

Figure 12. Test Circuit and Waveform Definition

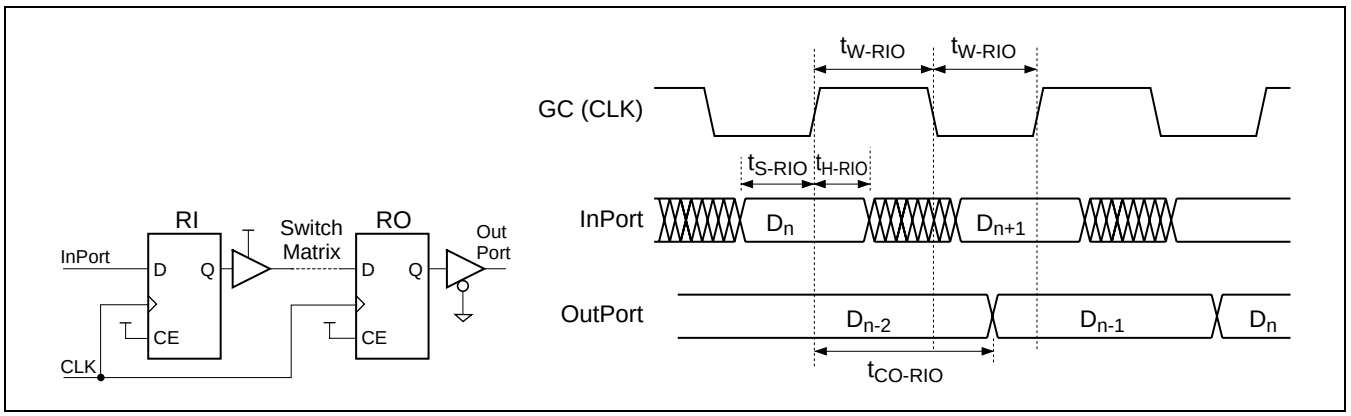

Figure 13. Registered Input and Registered Output Mode Timing (ICLK, OCLK Synchronized)

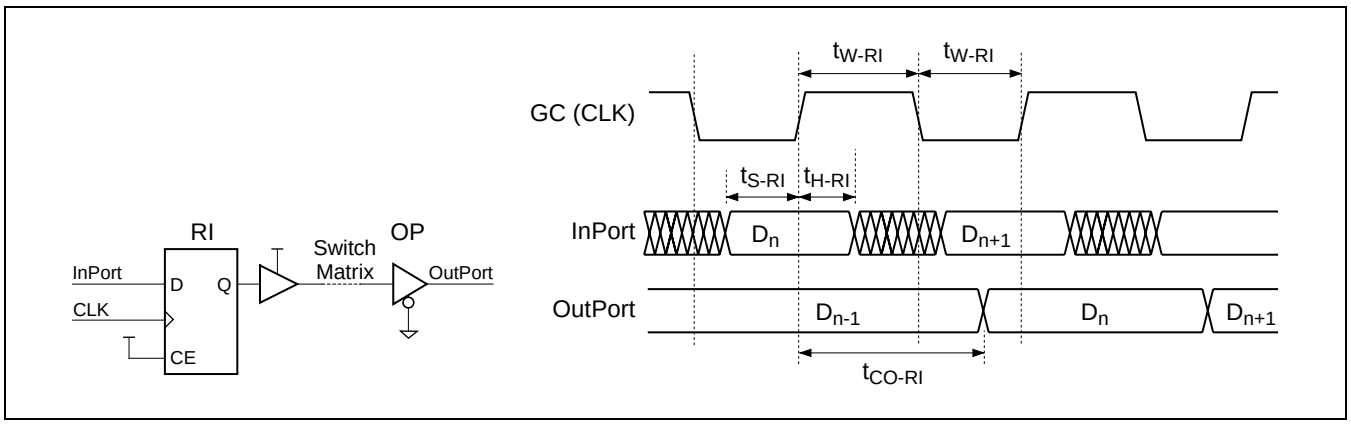

Figure 14. Registered Input Mode Timing

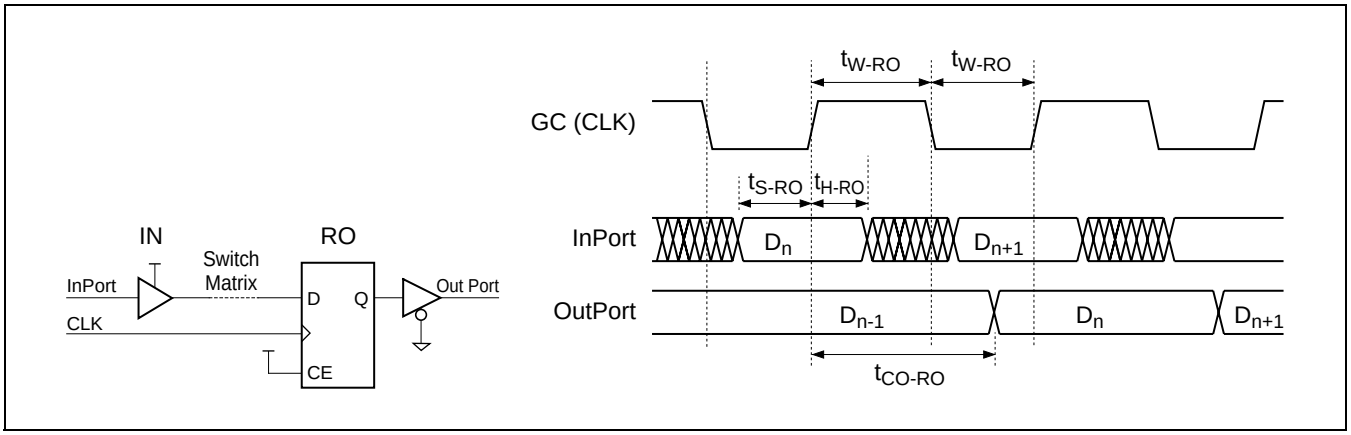

Figure 15. Registered Output Mode Timing

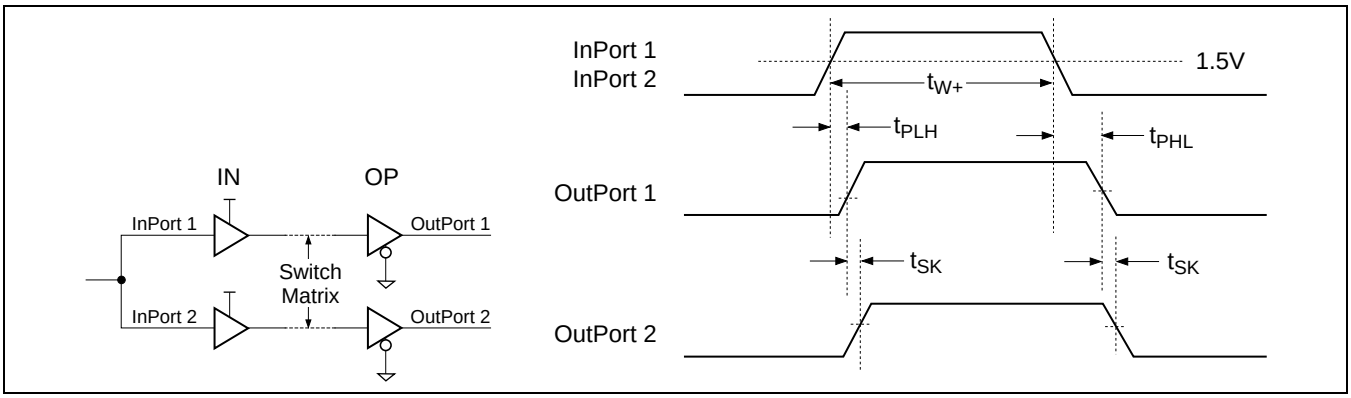

Figure 16. I/O Port Timing (Flow–through Mode)

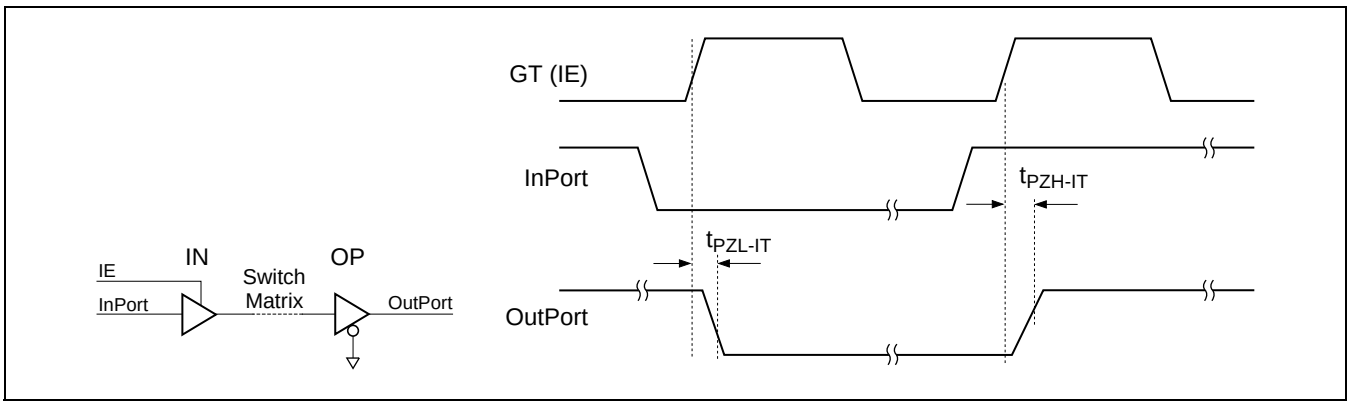

Figure 17. Input Enable Timing (Flow–through Mode)

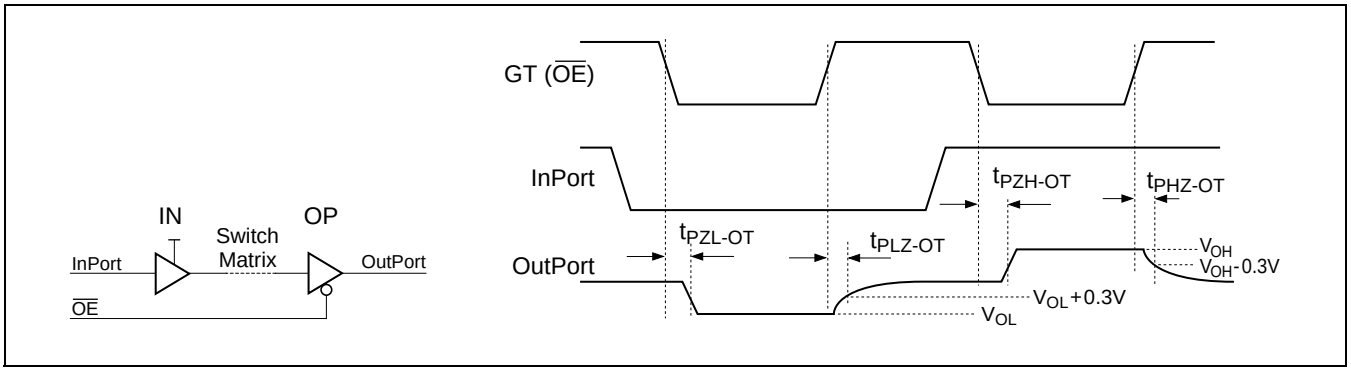

Figure 18. Output Enable Timing (Flow–through Mode)

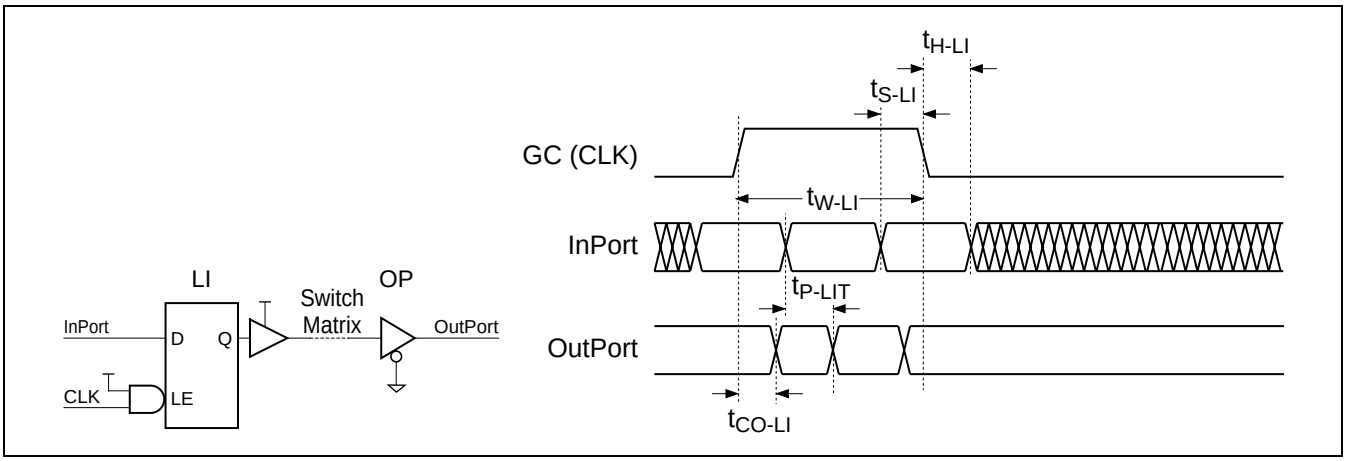

Figure 19. Latched Input Mode Timing

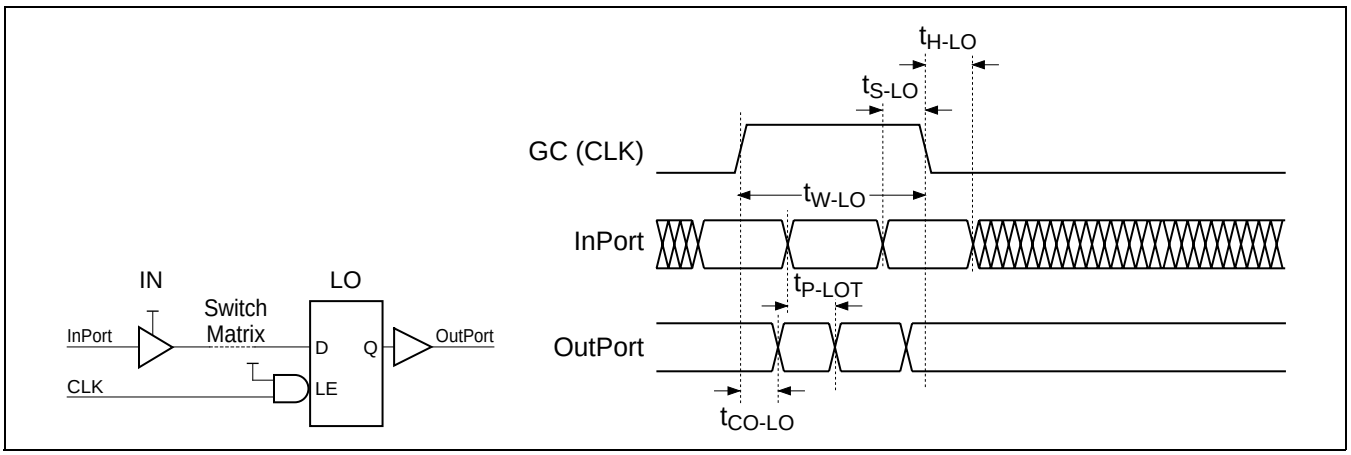

Figure 20. Latched Output Mode Timing

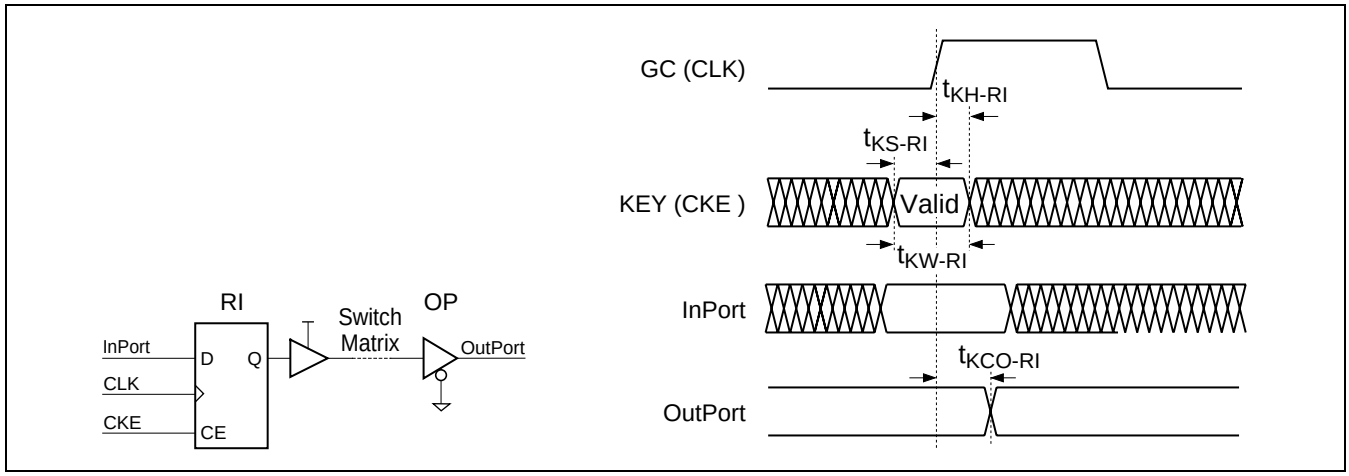

Figure 21. Key Timing for Register Input, Clock Enable (CKE)

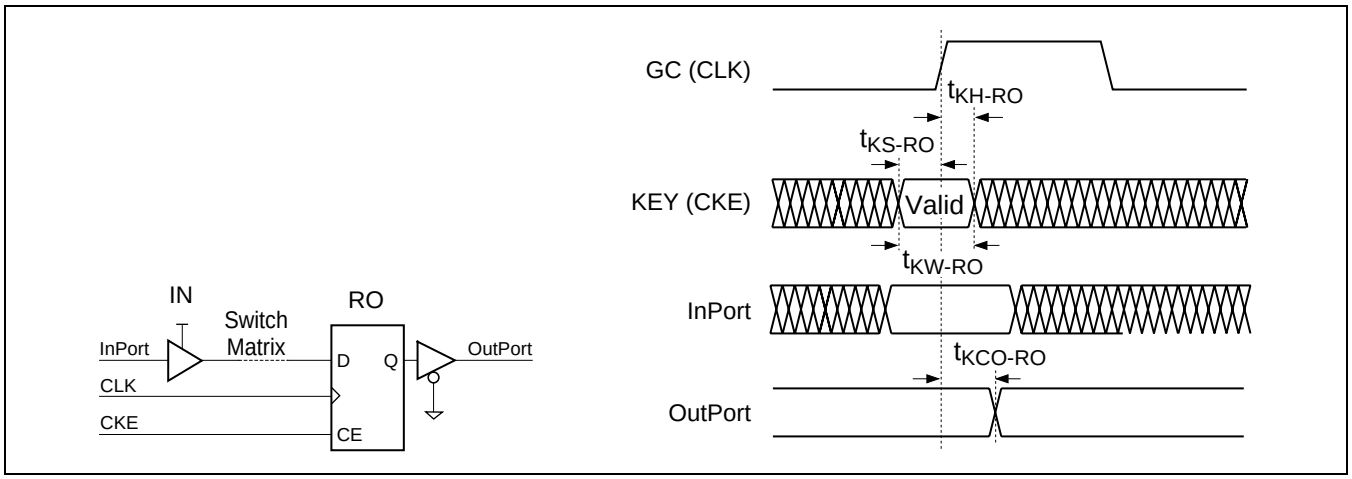

Figure 22. Key Timing for Register Output, Clock Enable (CKE)

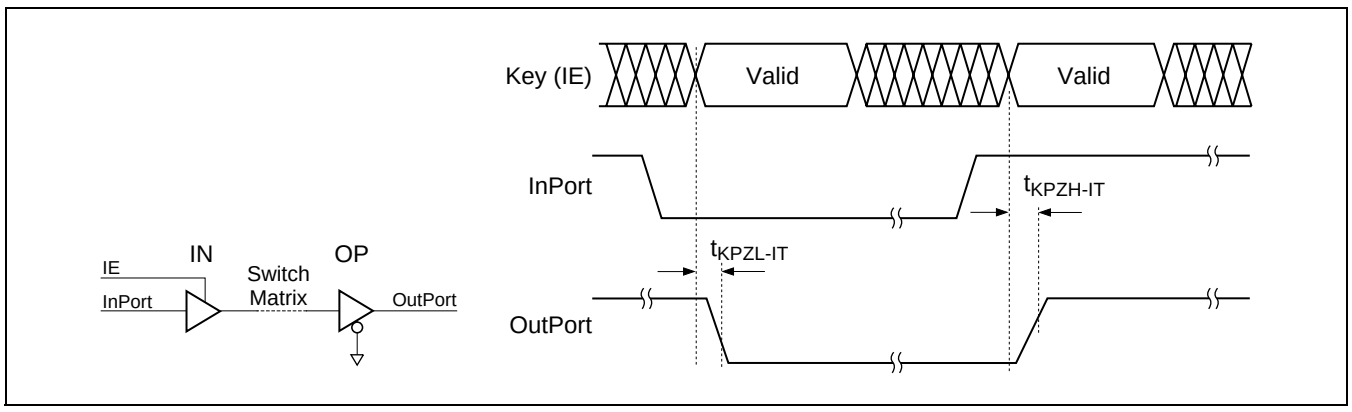

Figure 23. Key Timing for Input Enable

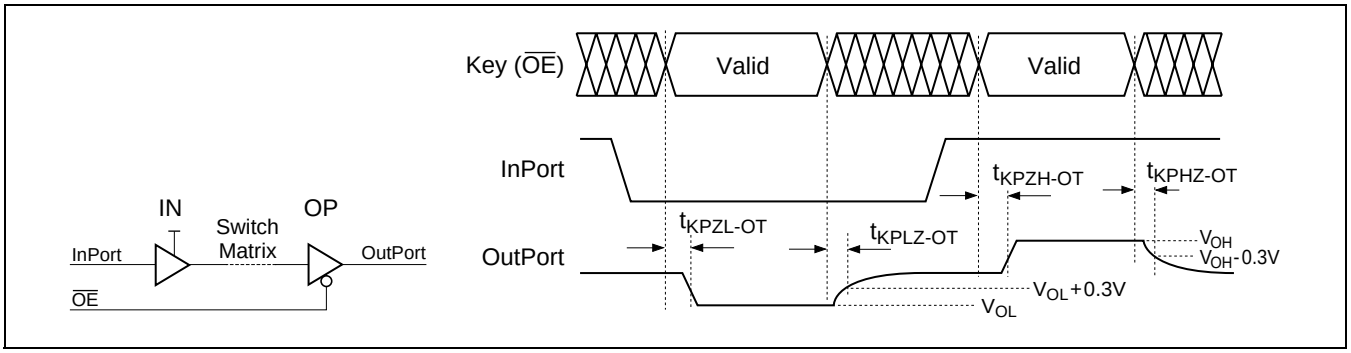

Figure 24. Key Timing for Output Enable

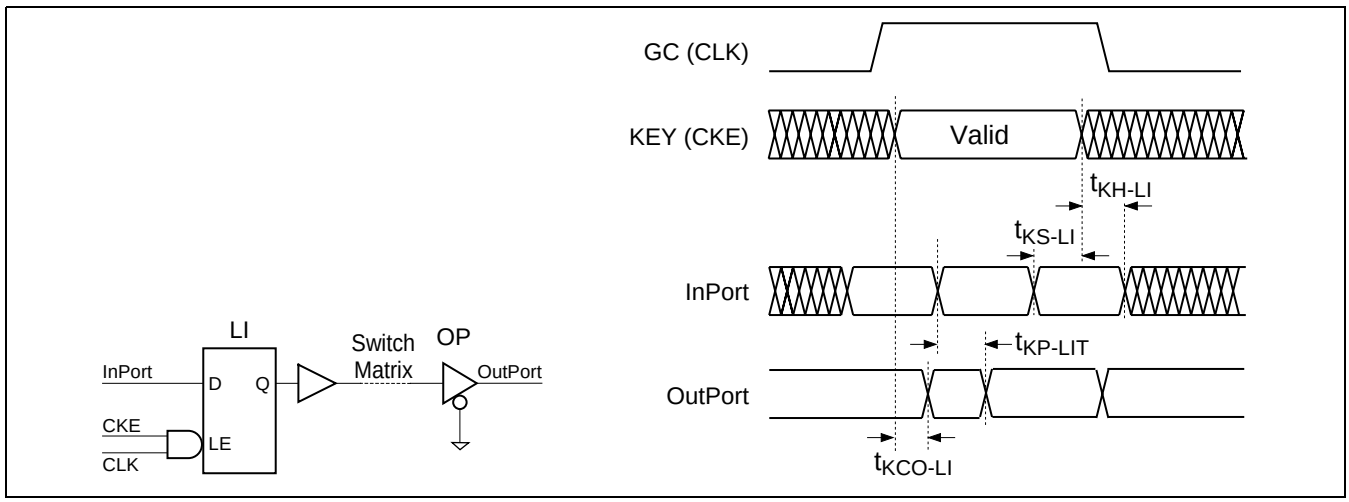

Figure 25. Key Timing for Latch Input, Enable (CKE)

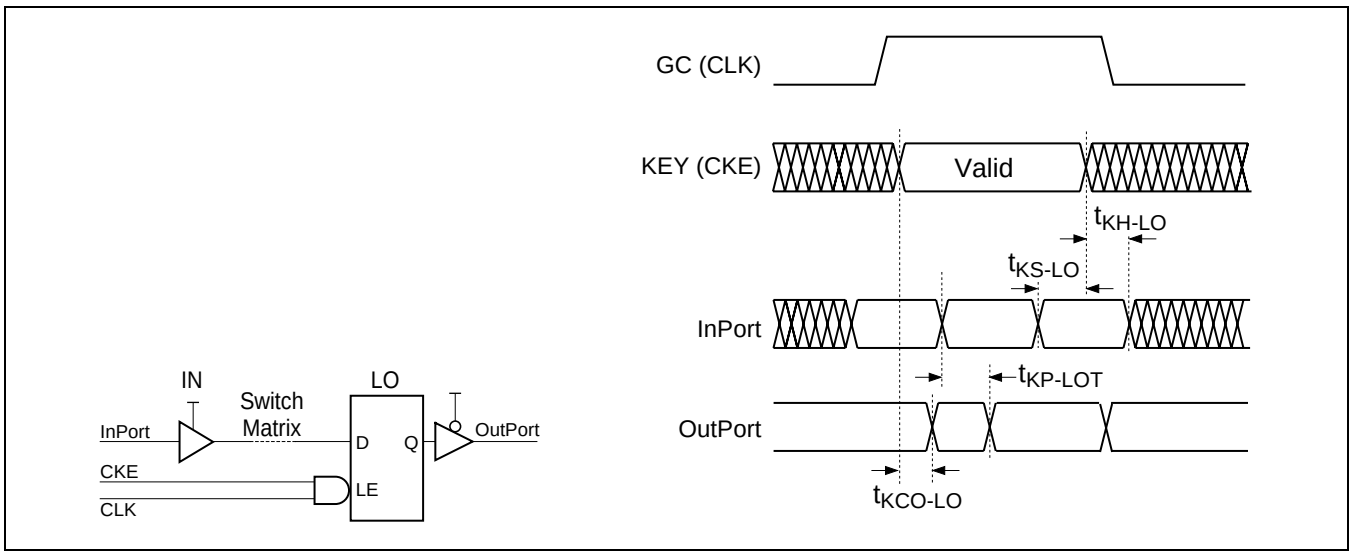

Figure 26. Key Timing for Latch Output, Enable (CKE)

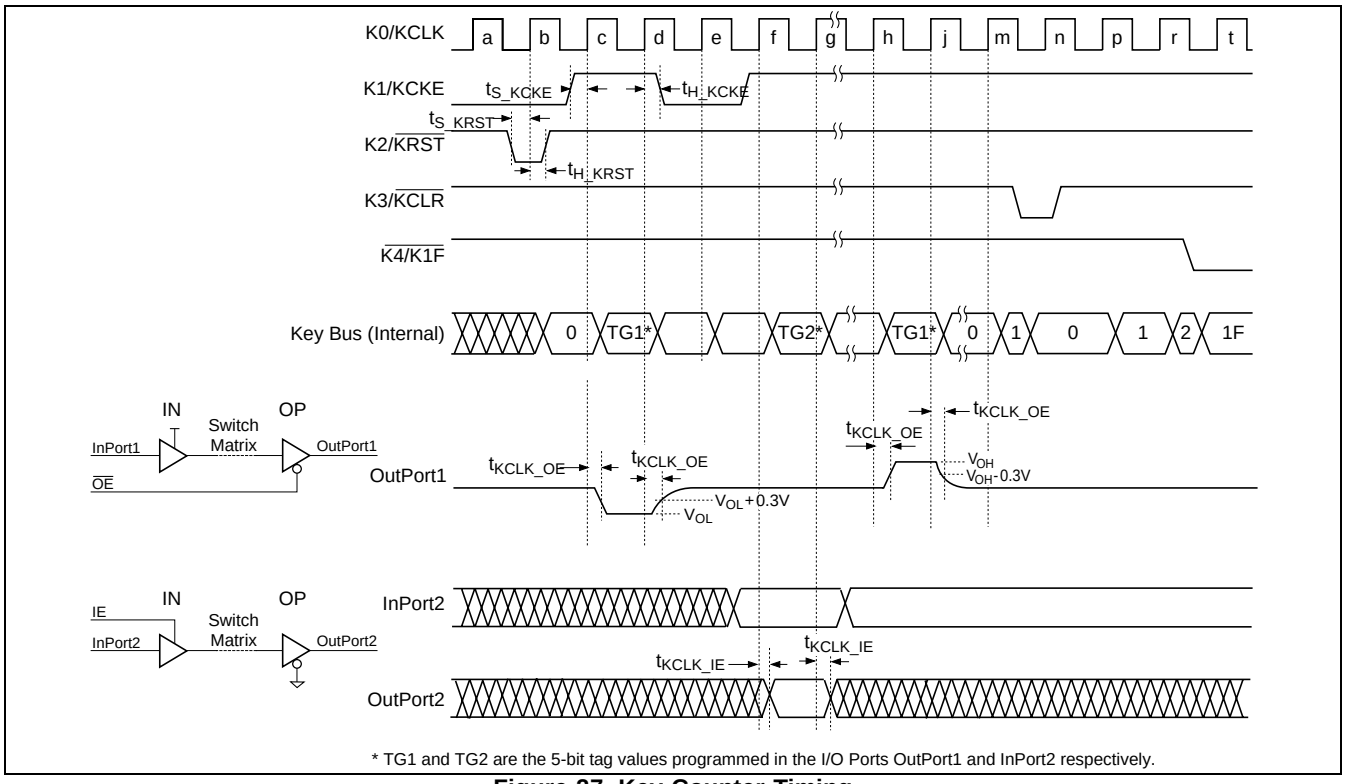

Figure 27. Key Counter Timing

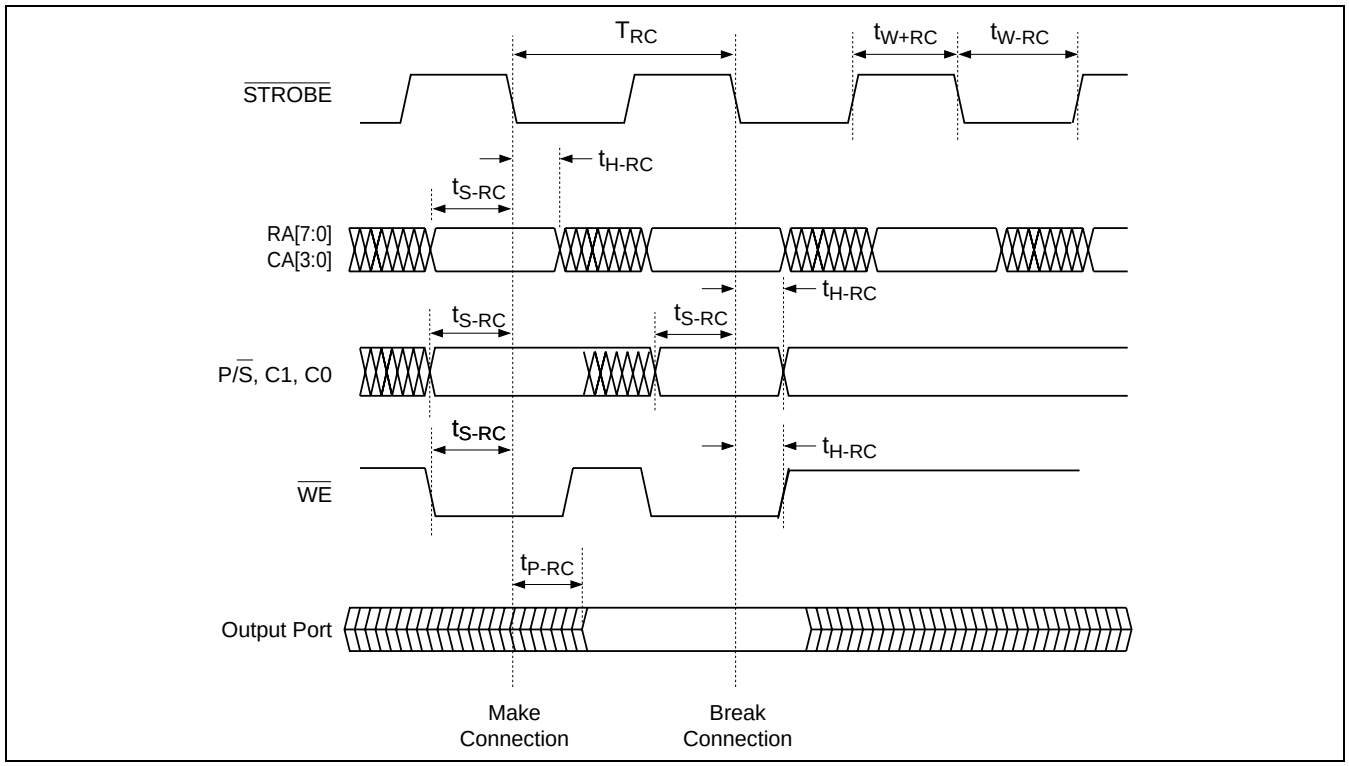

Figure 28. RapidConfigure Timing

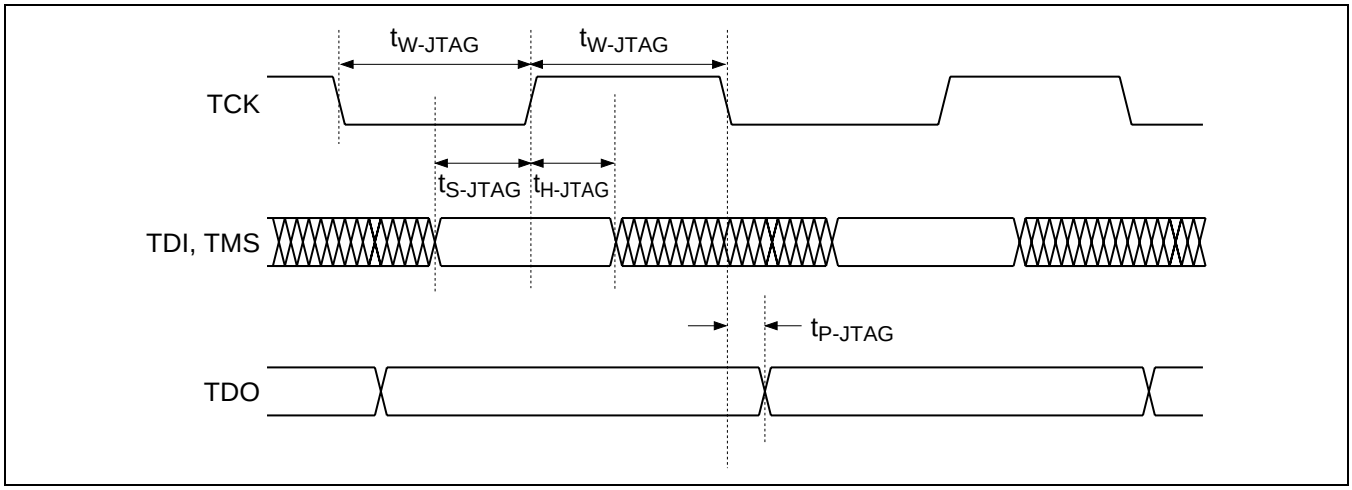

Figure 29. JTAG Timing

6.0 PINOUT

6.1 IQX320 [PBGA/416L] Package Pinout by Name

Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#
GC0	E2	P043	A18	P095	G26	P147	AA26	P199	AF15	P251	AB3	P303/CA7	H3	V_{DD}.PAD3	AF23
GC1	D1	P044	E15	P096	K24	P148	W23	P200	AD14	P252	X5	P304/CA8	L5	V_{DD}.PAD4	E1
GC2	E3	P045	B18	P097	G27	P149	AA25	P201	AE15	P253	AC1	P305	G1	V_{DD}.PAD4	H4
GC3	C3	P046	C16	P098	K25	P150	Y23	P202	AB14	P254	X4	P306/RA0	K4	V_{DD}.PAD4	J1
GT0	D22	P047	C18	P099	H25	P151	AC27	P203	AE14	P255	AB2	P307/RA1	G2	V_{DD}.PAD4	N2
GT1	E24	P048	D16	P100	L23	P152	U23	P204	AC14	P256	W5	P308/RA2	K5	V_{DD}.PAD4	P1
GT2	AB5	P049	B19	P101	H26	P153	AB25	P205	AE13	P257	AA3	P309/RA3	G3	V_{DD}.PAD4	R2
GT3	AA5	P050	E16	P102	L24	P154	AA24	P206	AD13	P258	W4	P310/RA4	J4	V_{DD}.PAD4	R3
GT4	D2	P051	C19	P103	J25	P155	AC26	P207	AE12	P259	AA2	P311/RA5	F2	V_{DD}.PAD4	V1
P000	D5	P052	C17	P104	L25	P156	AA23	P208	AC13	P260/GT12	V5	P312/RA6	J5	V_{DD}.PAD4	X1
P001	E14	P053	B20	P105	J26	P157	AD25	P209	AE11	P261/GT11	Y3	P313/RA7	H5	V_{DD}.PAD4	AB1
P002	E6	P054	D17	P106	M25	P158	AB23	P210	AB13	P262	V4	P314/RA8	G4	V_{DD}.X	F3
P003	E11	P055	C20	P107	J27	P159	AC25	P211	AF10	P263/GT10	Y2	P315/P/$\overline{S}$	G5	V_{SS}	A6
P004	D6	P056	E17	P108	M23	P160	AB22	P212	AC12	P264	V3	P316/C0	F4	V_{SS}	A11
P005	E9	P057	A21	P109	K26	P161	AD24	P213	AE10	P265/GT9	Y1	P317/C1	F5	V_{SS}	A12
P006	E8	P058	D18	P110	M24	P162	AC23	P214	AB12	P266	U5	P318/$\overline{WE}$	E5	V_{SS}	A16
P007	C6	P059	B21	P111	L26	P163	AE25	P215	AD10	P267/GT8	X3	P319/$\overline{STROBE}$	D3	V_{SS}	A17
P008	E7	P060	D19	P112	N23	P164	AB21	P216	AC11	P268/GC12	U4	RCE	C4	V_{SS}	A20
P009	B6	P061	C21	P113	M26	P165	AE24	P217	AE9	P269/GC11	X2	TCK	A4	V_{SS}	A22
P010	D7	P062	E18	P114	N24	P166	AC22	P218	AC10	P270/GC10	U3	TDI	B3	V_{SS}	AA1
P011	C7	P063	B22	P115	N27	P167	AD23	P219	AD9	P271/GC9	W3	TDO	C5	V_{SS}	AA27
P012	E10	P064	E19	P116	P25	P168	AC21	P220	AC9	P272/GC8	T5	TMS	B4	V_{SS}	AB24
P013	B7	P065	C22	P117	N26	P169	AF24	P221	AE8	P273/K4	W1	TRST*	B5	V_{SS}	AB26
P014	D9	P066	D20	P118	P23	P170	AB20	P222	AB11	P274	T4	V_{DD}	A19	V_{SS}	AC4
P015	A7	P067	B23	P119	R26	P171	AE23	P223	AD8	P275/K3	V2	V_{DD}	H27	V_{SS}	AC24
P016	D8	P068	E20	P120	P24	P172	AC20	P224	AC8	P276	T3	V_{DD}	W2	V_{SS}	AD26
P017	C8	P069	A24	P121	R27	P173	AD22	P225	AF7	P277/K2	U2	V_{DD}	AD12	V_{SS}	AE3
P018	D10	P070	D21	P122	R25	P174	AB19	P226	AB10	P278	R4	V_{DD}.PAD1	A5	V_{SS}	AF6
P019	B8	P071	C23	P123	T26	P175	AE22	P227	AE7	P279/K1	T2	V_{DD}.PAD1	A8	V_{SS}	AF8
P020	C10	P072	E21	P124	R24	P176	AC19	P228	AB8	P280	R5	V_{DD}.PAD1	A10	V_{SS}	AF11
P021	C9	P073	B24	P125	U26	P177	AD21	P229	AD7	P281/K0	R1	V_{DD}.PAD1	A14	V_{SS}	AF12
P022	D11	P074	E22	P126	R23	P178	AB18	P230	AB9	P282	P3	V_{DD}.PAD1	A23	V_{SS}	AF16
P023	B9	P075	C25	P127	V27	P179	AE21	P231	AE6	P283/GC7	P2	V_{DD}.PAD1	B13	V_{SS}	AF17
P024	C11	P076	C24	P128	T25	P180	AC18	P232	AB7	P284	P4	V_{DD}.PAD1	B15	V_{SS}	AF22
P025	A9	P077	D25	P129	V26	P181	AF21	P233	AD6	P285/GC6	N1	V_{DD}.PAD1	C13	V_{SS}	B25
P026	E12	P078	E23	P130	T24	P182	AD18	P234	AC7	P286	N3	V_{DD}.PAD2	E27	V_{SS}	C2
P027	B10	P079	C26	P131	V25	P183	AD20	P235	AE5	P287/GC5	M2	V_{DD}.PAD2	F23	V_{SS}	D4
P028	D12	P080	F24	P132	T23	P184	AB17	P236	AC6	P288	P5	V_{DD}.PAD2	K27	V_{SS}	D23
P029	B11	P081	D26	P133	W26	P185	AE20	P237	AF4	P289/GC4	L2	V_{DD}.PAD2	N25	V_{SS}	D24
P030	C12	P082	G23	P134	U25	P186	AC17	P238	AB6	P290	N4	V_{DD}.PAD2	P26	V_{SS}	E4
P031	B12	P083	E25	P135	W25	P187	AD19	P239	AD5	P291GT7	K1	V_{DD}.PAD2	P27	V_{SS}	F1
P032	E13	P084	G24	P136	U24	P188	AD17	P240	AC5	P292	M3	V_{DD}.PAD2	W27	V_{SS}	F27
P033	A13	P085	D27	P137	X26	P189	AE19	P241	AE4	P293/GT6	K2	V_{DD}.PAD2	X24	V_{SS}	H1
P034	D13	P086	H23	P138	V24	P190	AB16	P242	AD3	P294	L3	V_{DD}.PAD2	AB27	V_{SS}	L1
P035	B14	P087	E26	P139	X25	P191	AF19	P243	AD4	P295/GT5	K3	V_{DD}.PAD3	AD11	V_{SS}	L27
P036	C14	P088	H24	P140	W24	P192	AC16	P244	AB4	P296/CA0	N5	V_{DD}.PAD3	AD15	V_{SS}	M1
P037	A15	P089	F25	P141	Y27	P193	AE18	P245	AC3	P297/CA1	J2	V_{DD}.PAD3	AF5	V_{SS}	M27
P038	D14	P090	J23	P142	V23	P194	AD16	P246	AA4	P298/CA2	M5	V_{DD}.PAD3	AF9	V_{SS}	T1
P039	B16	P091	F26	P143	Y26	P195	AE17	P247	AD2	P299/CA3	J3	V_{DD}.PAD3	AF13	V_{SS}	T27
P040	C15	P092	J24	P144	Y24	P196	AC15	P248	Y5	P300/CA4	M4	V_{DD}.PAD3	AF14	V_{SS}	U1
P041	B17	P093	G25	P145	Y25	P197	AE16	P249	AC2	P301/CA5	H2	V_{DD}.PAD3	AF18	V_{SS}	U27
P042	D15	P094	K23	P146	X23	P198	AB15	P250	Y4	P302/CA6	L4	V_{DD}.PAD3	AF20	V_{SS}	X27

Table 21. IQX320 [PBGA/416L] Package Pinout by Name

6.2 IQX320 [PBGA/416L] Package Pinout by Location

Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name
A4	TCK	C11	P024	E11	P003	J24	P092	P27	V_{DD}.PAD2	X3	P267/GT8	AB26	V_{SS}	AD26	V_{SS}
A5	V_{DD}.PAD1	C12	P030	E12	P026	J25	P103	R1	P281/K0	X4	P254	AB27	V_{DD}.PAD2	AE3	V_{SS}
A6	V_{SS}	C13	V_{DD}.PAD1	E13	P032	J26	P105	R2	V_{DD}.PAD4	X5	P252	AC1	P253	AE4	P241
A7	P015	C14	P036	E14	P001	J27	P107	R3	V_{DD}.PAD4	X23	P146	AC2	P249	AE5	P235
A8	V_{DD}.PAD1	C15	P040	E15	P044	K1	P291/GT7	R4	P278	X24	V_{DD}.PAD2	AC3	P245	AE6	P231
A9	P025	C16	P046	E16	P050	K2	P293/GT6	R5	P280	X25	P139	AC4	V_{SS}	AE7	P227
A10	V_{DD}.PAD1	C17	P052	E17	P056	K3	P295/GT5	R23	P126	X26	P137	AC5	P240	AE8	P221
A11	V_{SS}	C18	P047	E18	P062	K4	P306/RA0	R24	P124	X27	V_{SS}	AC6	P236	AE9	P217
A12	V_{SS}	C19	P051	E19	P064	K5	P308/RA2	R25	P122	Y1	P265/GT9	AC7	P234	AE10	P213
A13	P033	C20	P055	E20	P068	K23	P094	R26	P119	Y2	P263/GT10	AC8	P224	AE11	P209
A14	V_{DD}.PAD1	C21	P061	E21	P072	K24	P096	R27	P121	Y3	P261/GT11	AC9	P220	AE12	P207
A15	P037	C22	P065	E22	P074	K25	P098	T1	V_{SS}	Y4	P250	AC10	P218	AE13	P205
A16	V_{SS}	C23	P071	E23	P078	K26	P109	T2	P279/K1	Y5	P248	AC11	P216	AE14	P203
A17	V_{SS}	C24	P076	E24	GT1	K27	V_{DD}.PAD2	T3	P276	Y23	P150	AC12	P212	AE15	P201
A18	P043	C25	P075	E25	P083	L1	V_{SS}	T4	P274	Y24	P144	AC13	P208	AE16	P197
A19	V_{DD}	C26	P079	E26	P087	L2	P289/GC4	T5	P272/GC8	Y25	P145	AC14	P204	AE17	P195
A20	V_{SS}	D1	GC1	E27	V_{DD}.PAD2	L3	P294	T23	P132	Y26	P143	AC15	P196	AE18	P193
A21	P057	D2	GT4	F1	V_{SS}	L4	P302/CA6	T24	P130	Y27	P141	AC16	P192	AE19	P189
A22	V_{SS}	D3	P319/STROBE	F2	P311/RA5	L5	P304/CA8	T25	P128	AA1	V_{SS}	AC17	P186	AE20	P185
A23	V_{DD}.PAD1	D4	V_{SS}	F3	V_{DD}.X	L23	P100	T26	P123	AA2	P259	AC18	P180	AE21	P179
A24	P069	D5	P000	F4	P316/C0	L24	P102	T27	V_{SS}	AA3	P257	AC19	P176	AE22	P175
B3	TDI	D6	P004	F5	P317/C1	L25	P104	U1	V_{SS}	AA4	P246	AC20	P172	AE23	P171
B4	TMS	D7	P010	F23	V_{DD}.PAD2	L26	P111	U2	P277/K2	AA5	GT3	AC21	P168	AE24	P165
B5	TRST*	D8	P016	F24	P080	L27	V_{SS}	U3	P270/GC10	AA23	P156	AC22	P166	AE25	P163
B6	P009	D9	P014	F25	P089	M1	V_{SS}	U4	P268/GC12	AA24	P154	AC23	P162	AF4	P237
B7	P013	D10	P018	F26	P091	M2	P287/GC5	U5	P266	AA25	P149	AC24	V_{SS}	AF5	V_{DD}.PAD3
B8	P019	D11	P022	F27	V_{SS}	M3	P292	U23	P152	AA26	P147	AC25	P159	AF6	V_{SS}
B9	P023	D12	P028	G1	P305	M4	P300/CA4	U24	P136	AA27	V_{SS}	AC26	P155	AF7	P225
B10	P027	D13	P034	G2	P307/RA1	M5	P298/CA2	U25	P134	AB1	V_{DD}.PAD4	AC27	P151	AF8	V_{SS}
B11	P029	D14	P038	G3	P309/RA3	M23	P108	U26	P125	AB2	P255	AD2	P247	AF9	V_{DD}.PAD3
B12	P031	D15	P042	G4	P314/RA8	M24	P110	U27	V_{SS}	AB3	P251	AD3	P242	AF10	P211
B13	V_{DD}.PAD1	D16	P048	G5	P315/P/S	M25	P106	V1	V_{DD}.PAD4	AB4	P244	AD4	P243	AF11	V_{SS}
B14	P035	D17	P054	G23	P082	M26	P113	V2	P275/K3	AB5	GT2	AD5	P239	AF12	V_{SS}
B15	V_{DD}.PAD1	D18	P058	G24	P084	M27	V_{SS}	V3	P264	AB6	P238	AD6	P233	AF13	V_{DD}.PAD3
B16	P039	D19	P060	G25	P093	N1	P285/GC6	V4	P262	AB7	P232	AD7	P229	AF14	V_{DD}.PAD3
B17	P041	D20	P066	G26	P095	N2	V_{DD}.PAD4	V5	P260/GT12	AB8	P228	AD8	P223	AF15	P199
B18	P045	D21	P070	G27	P097	N3	P286	V23	P142	AB9	P230	AD9	P219	AF16	V_{SS}
B19	P049	D22	GT0	H1	V_{SS}	N4	P290	V24	P138	AB10	P226	AD10	P215	AF17	V_{SS}
B20	P053	D23	V_{SS}	H2	P301/CA5	N5	P296/CA0	V25	P131	AB11	P222	AD11	V_{DD}.PAD3	AF18	V_{DD}.PAD3
B21	P059	D24	V_{SS}	H3	P303/CA7	N23	P112	V26	P129	AB12	P214	AD12	V_{DD}	AF19	P191
B22	P063	D25	P077	H4	V_{DD}.PAD4	N24	P114	V27	P127	AB13	P210	AD13	P206	AF20	V_{DD}.PAD3
B23	P067	D26	P081	H5	P313/RA7	N25	V_{DD}.PAD2	W1	P273/K4	AB14	P202	AD14	P200	AF21	P181
B24	P073	D27	P085	H23	P086	N26	P117	W2	V_{DD}	AB15	P198	AD15	V_{DD}.PAD3	AF22	V_{SS}
B25	V_{SS}	E1	V_{DD}.PAD4	H24	P088	N27	P115	W3	P271/GC9	AB16	P190	AD16	P194	AF23	V_{DD}.PAD3
C2	V_{SS}	E2	GC0	H25	P099	P1	V_{DD}.PAD4	W4	P258	AB17	P184	AD17	P188	AF24	P169
C3	GC3	E3	GC2	H26	P101	P2	P283/GC7	W5	P256	AB18	P178	AD18	P182		
C4	RCE	E4	V_{SS}	H27	V_{DD}	P3	P282	W23	P148	AB19	P174	AD19	P187		
C5	TDO	E5	P318/WE	J1	V_{DD}.PAD4	P4	P284	W24	P140	AB20	P170	AD20	P183		
C6	P007	E6	P002	J2	P297/CA1	P5	P288	W25	P135	AB21	P164	AD21	P177		
C7	P011	E7	P008	J3	P299/CA3	P23	P118	W26	P133	AB22	P160	AD22	P173		
C8	P017	E8	P006	J4	P310/RA4	P24	P120	W27	V_{DD}.PAD2	AB23	P158	AD23	P167		
C9	P021	E9	P005	J5	P312/RA6	P25	P116	X1	V_{DD}.PAD4	AB24	V_{SS}	AD24	P161		
C10	P020	E10	P012	J23	P090	P26	V_{DD}.PAD2	X2	P269/GC11	AB25	P153	AD25	P157		

Table 22. IQX320 [PBGA/416L] Package Pinout by Location

6.3 IQX320 [PBGA/416L] Package Footprint

	AF	AE	AD	AC	AB	AA	Y	X	W	V	U	T	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1				P253	$V_{DD}4$	V_{SS}	P265/	$V_{DD}4$	P273/	$V_{DD}4$	V_{SS}	V_{SS}	P281/	$V_{DD}4$	P285/	V_{SS}	V_{SS}	P291/	$V_{DD}4$	V_{SS}	P305/	V_{SS}	$V_{DD}4$	GC1				1
2			P247	P249	P255	P259	P263/	P269/	V_{DD}	P275/	P277/	P279/	$V_{DD}4$	P283/	$V_{DD}4$	P287/	P289/	P293/	P297/	P301/	P307/	P311/	GC0	GT4	V_{SS}			2
3		V_{SS}	P242	P245	P251	P257	P261/	P267/	P271/	P264	P270/	P276	$V_{DD}4$	P282	P286	P292	P294	P295/	P299/	P303/	P309/	V_{DD}.X	GC2	P319/	GC3	TDI		3
4	P237	P241	P243	V_{SS}	P244	P246	P250	P254	P258	P262	P268/	P274	P278	P284	P290	P300/	P302/	P306/	P310/	$V_{DD}4$	P314/	P316/	V_{SS}	V_{SS}	RCE	TMS	TCK	4
5	$V_{DD}3$	P235	P239	P240	GT2	GT3	P248	P252	P256	P260/	P266	P272/	P280	P288	P296/	P298/	P304/	P308/	P312/	P313/	P315/	P317/	P318/	P000	TDO	TRST*	$V_{DD}1$	5
6	V_{SS}	P231	P233	P236	P238																		P002	P004	P007	P009	V_{SS}	6
7	P225	P227	P229	P234	P232																		P008	P010	P011	P013	P015	7
8	V_{SS}	P221	P223	P224	P228																		P006	P016	P017	P019	$V_{DD}1$	8
9	$V_{DD}3$	P217	P219	P220	P230																		P005	P014	P021	P023	P025	9
10	P211	P213	P215	P218	P226																		P012	P018	P020	P027	$V_{DD}1$	10
11	V_{SS}	P209	$V_{DD}3$	P216	P222																		P003	P022	P024	P029	V_{SS}	11
12	V_{SS}	P207	V_{DD}	P212	P214																		P026	P028	P030	P031	V_{SS}	12
13	$V_{DD}3$	P205	P206	P208	P210																		P032	P034	$V_{DD}1$	$V_{DD}1$	P033	13
14	$V_{DD}3$	P203	P200	P204	P202																		P001	P038	P036	P035	$V_{DD}1$	14
15	P199	P201	$V_{DD}3$	P196	P198																		P044	P042	P040	$V_{DD}1$	P037	15
16	V_{SS}	P197	P194	P192	P190																		P050	P048	P046	P039	V_{SS}	16
17	V_{SS}	P195	P188	P186	P184																		P056	P054	P052	P041	V_{SS}	17
18	$V_{DD}3$	P193	P182	P180	P178																		P062	P058	P047	P045	P043	18
19	P191	P189	P187	P176	P174																		P064	P060	P051	P049	V_{DD}	19
20	$V_{DD}3$	P185	P183	P172	P170																		P068	P066	P055	P053	V_{SS}	20
21	P181	P179	P177	P168	P164																		P072	P070	P061	P059	P057	21
22	V_{SS}	P175	P173	P166	P160																		P074	GT0	P065	P063	V_{SS}	22
23	$V_{DD}3$	P171	P167	P162	P158	P156	P150	P146	P148	P142	P152	P132	P126	P118	P112	P108	P100	P094	P090	P086	P082	$V_{DD}2$	P078	V_{SS}	P071	P067	$V_{DD}1$	23
24	P169	P165	P161	V_{SS}	V_{SS}	P154	P144	$V_{DD}2$	P140	P138	P136	P130	P124	P120	P114	P110	P102	P096	P092	P088	P084	P080	GT1	V_{SS}	P076	P073	P069	24
25		P163	P157	P159	P153	P149	P145	P139	P135	P131	P134	P128	P122	P116	$V_{DD}2$	P106	P104	P098	P103	P099	P093	P089	P083	P077	P075	V_{SS}		25
26			V_{SS}	P155	V_{SS}	P147	P143	P137	P133	P129	P125	P123	P119	$V_{DD}2$	P117	P113	P111	P109	P105	P101	P095	P091	P087	P081	P079			26
27				P151	$V_{DD}2$	V_{SS}	P141	V_{SS}	$V_{DD}2$	P127	V_{SS}	V_{SS}	P121	$V_{DD}2$	P115	V_{SS}	V_{SS}	$V_{DD}2$	P107	V_{DD}	P097	V_{SS}	$V_{DD}2$	P085				27
	AF	AE	AD	AC	AB	AA	Y	X	W	V	U	T	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

Figure 30. IQX320 [PBGA/416L] Package Footprint

Notes:

(1) $V_{DD}1$ - V_{DD}.PAD1
(2) $V_{DD}2$ - V_{DD}.PAD2
(3) $V_{DD}3$ - V_{DD}.PAD3
(4) $V_{DD}4$ - V_{DD}.PAD4
(5) Pxxx/ - Port is dual function

6.4 IQX240B [PQFP/304L] Package Pinout by Name

Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#
GC0	12	P029	262	P067	215	P105	171	P143	125	P181	78	P219/CA3	30	V_{DD}.PAD2	178
GC1	9	P030	261	P068	214	P106	170	P144	124	P182	75	P220/CA4	29	V_{DD}.PAD2	192
GC2	7	P031	260	P069	213	P107	169	P145	123	P183	74	P221/CA5	27	V_{DD}.PAD2	221
GC3	3	P032	259	P070	212	P108	168	P146	122	P184	73	P222/CA6	26	V_{DD}.PAD3	84
GT0	229	P033	258	P071	209	P109	167	P147	121	P185	72	P223/CA7	25	V_{DD}.PAD3	147
GT1	228	P034	257	P072	208	P110	164	P148	120	P186	70	P224/CA8	24	V_{DD}.PAD3	101
GT2	77	P035	256	P073	207	P111	163	P149	117	P187	69	P225	23	V_{DD}.PAD3	119
GT3	76	P036	255	P074	206	P112	162	P150	116	P188	68	P226/RA0	22	V_{DD}.PAD3	131
GT4	5	P037	254	P075	205	P113	161	P151	115	P189	67	P227/RA1	19	V_{DD}.PAD4	20
P000	303	P038	251	P076	204	P114	160	P152	114	P190	66	P228/RA2	18	V_{DD}.PAD4	35
P001	300	P039	250	P077	203	P115	157	P153	111	P191	65	P229/RA3	17	V_{DD}.PAD4	48
P002	295	P040	249	P078	202	P116	156	P154	110	P192	64	P230/RA4	16	V_{DD}.PAD4	60
P003	293	P041	248	P079	201	P117	155	P155	109	P193	63	P231/RA5	15	V_{DD}.X	28
P004	292	P042	247	P080	200	P118	154	P156	108	P194/GT12	62	P232/RA6	14	V_{SS}	10
P005	291	P043	246	P081	199	P119	153	P157	107	P195/GT11	59	P233/RA7	13	V_{SS}	21
P006	290	P044	245	P082	198	P120	152	P158	106	P196/GT10	58	P234/RA8	11	V_{SS}	36
P007	288	P045	244	P083	197	P121	151	P159	105	P197/GT9	57	P235/P/$\overline{S}$	8	V_{SS}	49
P008	287	P046	243	P084	196	P122	150	P160	104	P198/GT8	55	P236/C0	6	V_{SS}	61
P009	286	P047	240	P085	195	P123	149	P161	103	P199/GC12	54	P237/C1	4	V_{SS}	71
P010	285	P048	239	P086	194	P124	148	P162	102	P200/GC11	53	P238/WE	2	V_{SS}	83
P011	284	P049	238	P087	191	P125	145	P163	99	P201/GC10	52	P239/STROBE	1	V_{SS}	90
P012	283	P050	237	P088	190	P126	144	P164	98	P202/GC9	51	RCE	304	V_{SS}	100
P013	282	P051	236	P089	189	P127	143	P165	97	P203/GC8	50	TCK	298	V_{SS}	112
P014	281	P052	234	P090	188	P128	142	P166	96	P204/K4	47	TDI	302	V_{SS}	118
P015	280	P053	233	P091	187	P129	141	P167	95	P205/K3	46	TDO	299	V_{SS}	130
P016	277	P054	232	P092	186	P130	140	P168	94	P206/K2	45	TMS	301	V_{SS}	146
P017	276	P055	231	P093	185	P131	139	P169	93	P207/K1	44	TRST*	294	V_{SS}	159
P018	275	P056	230	P094	184	P132	138	P170	92	P208/K0	43	V_{DD}	56	V_{SS}	166
P019	274	P057	227	P095	183	P133	137	P171	91	P209/GC7	42	V_{DD}	113	V_{SS}	179
P020	273	P058	226	P096	182	P134	136	P172	89	P210/GC6	41	V_{DD}	210	V_{SS}	193
P021	272	P059	225	P097	181	P135	135	P173	88	P211/GC5	40	V_{DD}	242	V_{SS}	211
P022	271	P060	224	P098	180	P136	134	P174	87	P212/GC4	39	V_{DD}.PAD1	235	V_{SS}	222
P023	270	P061	223	P099	177	P137	133	P175	86	P213/GT7	38	V_{DD}.PAD1	253	V_{SS}	241
P024	269	P062	220	P100	176	P138	132	P176	85	P214/GT6	37	V_{DD}.PAD1	267	V_{SS}	252
P025	268	P063	219	P101	175	P139	129	P177	82	P215/GT5	34	V_{DD}.PAD1	279	V_{SS}	266
P026	265	P064	218	P102	174	P140	128	P178	81	P216/CA0	33	V_{DD}.PAD1	297	V_{SS}	278
P027	264	P065	217	P103	173	P141	127	P179	80	P217/CA1	32	V_{DD}.PAD2	158	V_{SS}	289
P028	263	P066	216	P104	172	P142	126	P180	79	P218/CA2	31	V_{DD}.PAD2	165	V_{SS}	296

Table 23. IQX240B [PQFP/304L] Package Pinout by Name

6.5 IQX240B [PQFP/304L] Package Pinout by Location

Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name
1	P239/STROBE	39	P212/GC4	77	GT2	115	P151	153	P119	191	P087	229	GT0	267	V_{DD}.PAD1
2	P238/WE	40	P211/GC5	78	P181	116	P150	154	P118	192	V_{DD}.PAD2	230	P056	268	P025
3	GC3	41	P210/GC6	79	P180	117	P149	155	P117	193	V_{SS}	231	P055	269	P024
4	P237/C1	42	P209/GC7	80	P179	118	V_{SS}	156	P116	194	P086	232	P054	270	P023
5	GT4	43	P208/K0	81	P178	119	V_{DD}.PAD3	157	P115	195	P085	233	P053	271	P022
6	P236/C0	44	P207/K1	82	P177	120	P148	158	V_{DD}.PAD2	196	P084	234	P052	272	P021
7	GC2	45	P206/K2	83	V_{SS}	121	P147	159	V_{SS}	197	P083	235	V_{DD}.PAD1	273	P020
8	P235/P/$\overline{S}$	46	P205/K3	84	V_{DD}.PAD3	122	P146	160	P114	198	P082	236	P051	274	P019
9	GC1	47	P204/K4	85	P176	123	P145	161	P113	199	P081	237	P050	275	P018
10	V_{SS}	48	V_{DD}.PAD4	86	P175	124	P144	162	P112	200	P080	238	P049	276	P017
11	P234/RA8	49	V_{SS}	87	P174	125	P143	163	P111	201	P079	239	P048	277	P016
12	GC0	50	P203/GC8	88	P173	126	P142	164	P110	202	P078	240	P047	278	V_{SS}
13	P233/RA7	51	P202/GC9	89	P172	127	P141	165	V_{DD}.PAD2	203	P077	241	V_{SS}	279	V_{DD}.PAD1
14	P232/RA6	52	P201/GC10	90	V_{SS}	128	P140	166	V_{SS}	204	P076	242	V_{DD}	280	P015
15	P231/RA5	53	P200/GC11	91	P171	129	P139	167	P109	205	P075	243	P046	281	P014
16	P230/RA4	54	P199/GC12	92	P170	130	V_{SS}	168	P108	206	P074	244	P045	282	P013
17	P229/RA3	55	P198/GT8	93	P169	131	V_{DD}.PAD3	169	P107	207	P073	245	P044	283	P012
18	P228/RA2	56	V_{DD}	94	P168	132	P138	170	P106	208	P072	246	P043	284	P011
19	P227/RA1	57	P197/GT9	95	P167	133	P137	171	P105	209	P071	247	P042	285	P010
20	V_{DD}.PAD4	58	P196/GT10	96	P166	134	P136	172	P104	210	V_{DD}	248	P041	286	P009
21	V_{SS}	59	P195/GT11	97	P165	135	P135	173	P103	211	V_{SS}	249	P040	287	P008
22	P226/RA0	60	V_{DD}.PAD4	98	P164	136	P134	174	P102	212	P070	250	P039	288	P007
23	P225	61	V_{SS}	99	P163	137	P133	175	P101	213	P069	251	P038	289	V_{SS}
24	P224/CA8	62	P194/GT12	100	V_{SS}	138	P132	176	P100	214	P068	252	V_{SS}	290	P006
25	P223/CA7	63	P193	101	V_{DD}.PAD3	139	P131	177	P099	215	P067	253	V_{DD}.PAD1	291	P005
26	P222/CA6	64	P192	102	P162	140	P130	178	V_{DD}.PAD2	216	P066	254	P037	292	P004
27	P221/CA5	65	P191	103	P161	141	P129	179	V_{SS}	217	P065	255	P036	293	P003
28	V_{DD}.X	66	P190	104	P160	142	P128	180	P098	218	P064	256	P035	294	TRST*
29	P220/CA4	67	P189	105	P159	143	P127	181	P097	219	P063	257	P034	295	P002
30	P219/CA3	68	P188	106	P158	144	P126	182	P096	220	P062	258	P033	296	V_{SS}
31	P218/CA2	69	P187	107	P157	145	P125	183	P095	221	V_{DD}.PAD2	259	P032	297	V_{DD}.PAD1
32	P217/CA1	70	P186	108	P156	146	V_{SS}	184	P094	222	V_{SS}	260	P031	298	TCK
33	P216/CA0	71	V_{SS}	109	P155	147	V_{DD}.PAD3	185	P093	223	P061	261	P030	299	TDO
34	P215/GT5	72	P185	110	P154	148	P124	186	P092	224	P060	262	P029	300	P001
35	V_{DD}.PAD4	73	P184	111	P153	149	P123	187	P091	225	P059	263	P028	301	TMS
36	V_{SS}	74	P183	112	V_{SS}	150	P122	188	P090	226	P058	264	P027	302	TDI
37	P214/GT6	75	P182	113	V_{DD}	151	P121	189	P089	227	P057	265	P026	303	P000
38	P213/GT7	76	GT3	114	P152	152	P120	190	P088	228	GT1	266	V_{SS}	304	RCE

Table 24. IQX240B [PQFP/304L] Package Pinout by Location

6.6 IQX240B [PQFP/304L] Package Pinout

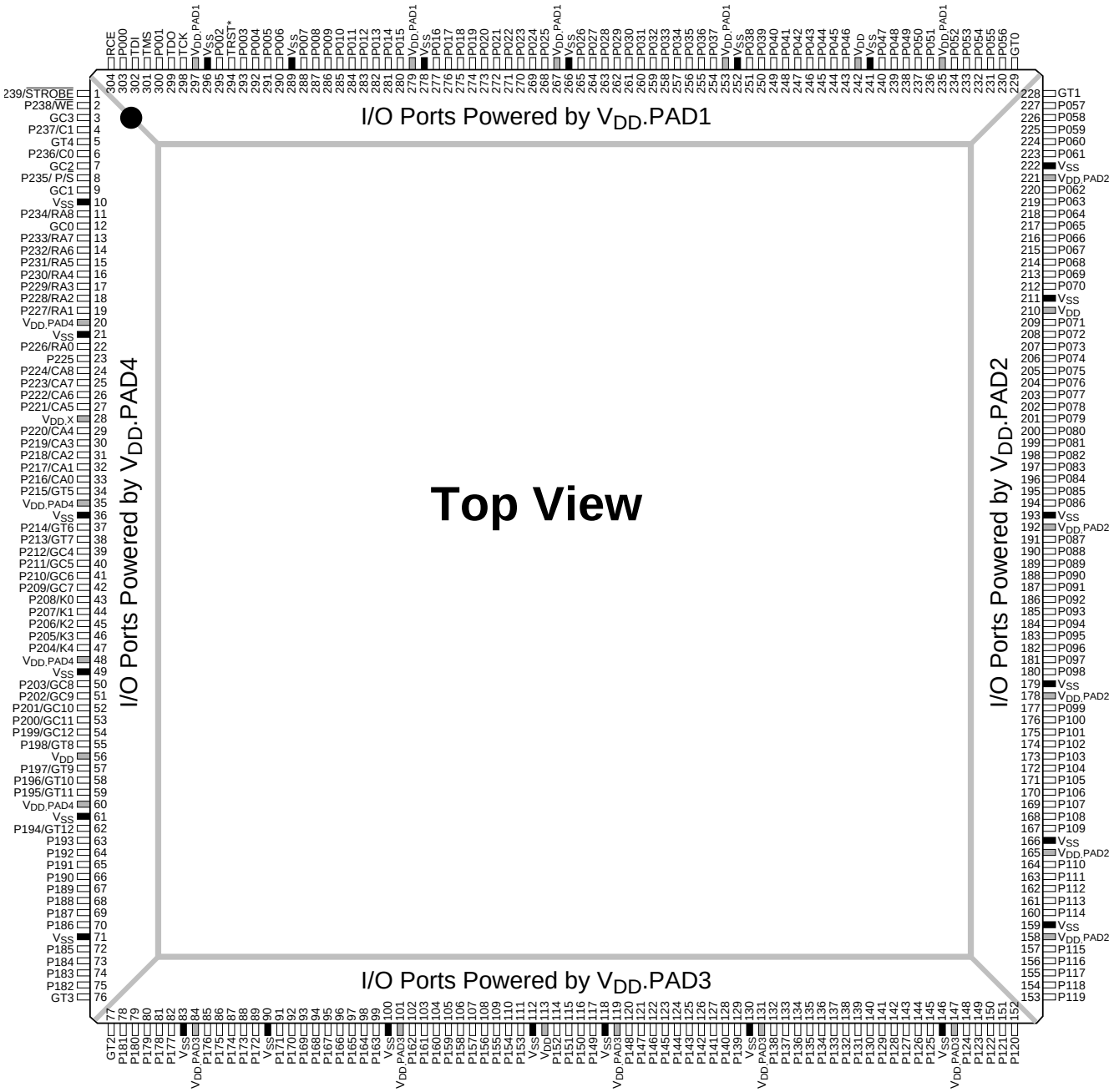

Figure 31. IQX240B [PQFP/304L] Package Pinout

6.7 IQX160 [PQFP/208L] Package Pinout by Name

Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#
GC0	10	P046	145	P098	82	P150/RA2	16
GC1	7	P047	144	P099	81	P151/RA3	15
GT0	157	P048	143	P100	80	P152/RA4	14
GT1	156	P049	142	P101	78	P153/RA5	13
GT2	53	P050	140	P102	77	P154/RA6	12
GT3	52	P051	139	P103	76	P155/RA7	11
P000	203	P052	138	P104/GT12	74	P156/C0	5
P001	202	P053	137	P105/GT11	73	P157/C1	4
P002	201	P054	136	P106/GT10	72	P158/$\overline{WE}$	3
P003	200	P055	135	P107	71	P159/$\overline{STROBE}$	2
P004	198	P056	132	P108/GT9	70	RCE	6
P005	197	P057	131	P109/GT8	69	TCK	206
P006	196	P058	130	P110/GC12	67	TDI	1
P007	195	P059	129	P111/GC11	66	TDO	207
P008	194	P060	128	P112/GC10	65	TMS	208
P009	192	P061	127	P113	64	TRST*	204
P010	191	P062	125	P114/GC9	63	V_{DD}	29
P011	190	P063	124	P115/GC8	62	V_{DD}	133
P012	189	P064	123	P116/K4	59	V_{DD}.PAD1	119
P013	188	P065	122	P117/K3	58	V_{DD}.PAD1	164
P014	187	P066	121	P118	57	V_{DD}.PAD1	186
P015	184	P067	120	P119	56	V_{DD}.PAD1	205
P016	183	P068	117	P120/K2	55	V_{DD}.PAD2	8
P017	182	P069	116	P121/K1	54	V_{DD}.PAD2	45
P018	181	P070	115	P122/K0	51	V_{DD}.PAD2	61
P019	180	P071	114	P123	50	V_{DD}.PAD2	79
P020	179	P072	113	P124	49	V_{DD}.PAD2	98
P021	177	P073	112	P125/GC7	48	V_{DD}.X	148
P022	176	P074	110	P126/GC6	47	V_{SS}	9
P023	175	P075	109	P127/GC5	44	V_{SS}	18
P024	174	P076	108	P128/GC4	43	V_{SS}	23
P025	173	P077	107	P129	42	V_{SS}	31
P026	172	P078	106	P130	41	V_{SS}	38
P027	170	P079	105	P131/GT7	40	V_{SS}	46
P028	169	P080	104	P132/GT6	39	V_{SS}	60
P029	168	P081	103	P133/GT5	37	V_{SS}	68
P030	167	P082	102	P134/GT4	36	V_{SS}	75
P031	166	P083	101	P135	35	V_{SS}	83
P032	165	P084	100	P136	34	V_{SS}	90
P033	162	P085	99	P137/GC3	33	V_{SS}	97
P034	161	P086	96	P138/GC2	32	V_{SS}	111
P035	160	P087	95	P139/ P/$\overline{S}$	30	V_{SS}	118
P036	159	P088	94	P140/CA0	28	V_{SS}	126
P037	158	P089	93	P141/CA1	27	V_{SS}	134
P038	155	P090	92	P142/CA2	26	V_{SS}	141
P039	154	P091	91	P143/CA3	25	V_{SS}	149
P040	153	P092	89	P144/CA4	24	V_{SS}	163
P041	152	P093	88	P145/CA5	22	V_{SS}	171
P042	151	P094	87	P146/CA6	21	V_{SS}	178
P043	150	P095	86	P147/CA7	20	V_{SS}	185
P044	147	P096	85	P148/RA0	19	V_{SS}	193
P045	146	P097	84	P149/RA1	17	V_{SS}	199

Table 25. IQX160 [PQFP/208L] Package Pinout by Name

6.8 IQX160 [PQFP/208L] Package Pinout by Location

Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name
1	TDI	53	GT2	105	P079	157	GT0
2	P159/STROBE	54	P121/K1	106	P078	158	P037
3	P158/WE	55	P120/K2	107	P077	159	P036
4	P157/C1	56	P119	108	P076	160	P035
5	P156/C0	57	P118	109	P075	161	P034
6	RCE	58	P117/K3	110	P074	162	P033
7	GC1	59	P116/K4	111	V_{SS}	163	V_{SS}
8	V_{DD}.PAD2	60	V_{SS}	112	P073	164	V_{DD}.PAD1
9	V_{SS}	61	V_{DD}.PAD2	113	P072	165	P032
10	GC0	62	P115/GC8	114	P071	166	P031
11	P155/RA7	63	P114/GC9	115	P070	167	P030
12	P154/RA6	64	P113	116	P069	168	P029
13	P153/RA5	65	P112/GC10	117	P068	169	P028
14	P152/RA4	66	P111/GC11	118	V_{SS}	170	P027
15	P151/RA3	67	P110/GC12	119	V_{DD}.PAD1	171	V_{SS}
16	P150/RA2	68	V_{SS}	120	P067	172	P026
17	P149/RA1	69	P109/GT8	121	P066	173	P025
18	V_{SS}	70	P108/GT9	122	P065	174	P024
19	P148/RA0	71	P107	123	P064	175	P023
20	P147/CA7	72	P106/GT10	124	P063	176	P022
21	P146/CA6	73	P105/GT11	125	P062	177	P021
22	P145/CA5	74	P104/GT12	126	V_{SS}	178	V_{SS}
23	V_{SS}	75	V_{SS}	127	P061	179	P020
24	P144/CA4	76	P103	128	P060	180	P019
25	P143/CA3	77	P102	129	P059	181	P018
26	P142/CA2	78	P101	130	P058	182	P017
27	P141/CA1	79	V_{DD}.PAD2	131	P057	183	P016
28	P140/CA0	80	P100	132	P056	184	P015
29	V_{DD}	81	P099	133	V_{DD}	185	V_{SS}
30	P139/ P/$\overline{S}$	82	P098	134	V_{SS}	186	V_{DD}.PAD1
31	V_{SS}	83	V_{SS}	135	P055	187	P014
32	P138/GC2	84	P097	136	P054	188	P013
33	P137/GC3	85	P096	137	P053	189	P012
34	P136	86	P095	138	P052	190	P011
35	P135	87	P094	139	P051	191	P010
36	P134/GT4	88	P093	140	P050	192	P009
37	P133/GT5	89	P092	141	V_{SS}	193	V_{SS}
38	V_{SS}	90	V_{SS}	142	P049	194	P008
39	P132/GT6	91	P091	143	P048	195	P007
40	P131/GT7	92	P090	144	P047	196	P006
41	P130	93	P089	145	P046	197	P005
42	P129	94	P088	146	P045	198	P004
43	P128/GC4	95	P087	147	P044	199	V_{SS}
44	P127/GC5	96	P086	148	V_{DD}.X	200	P003
45	V_{DD}.PAD2	97	V_{SS}	149	V_{SS}	201	P002
46	V_{SS}	98	V_{DD}.PAD2	150	P043	202	P001
47	P126/GC6	99	P085	151	P042	203	P000
48	P125/GC7	100	P084	152	P041	204	TRST*
49	P124	101	P083	153	P040	205	V_{DD}.PAD1
50	P123	102	P082	154	P039	206	TCK
51	P122/K0	103	P081	155	P038	207	TDO
52	GT3	104	P080	156	GT1	208	TMS

Table 26. IQX160 [PQFP/208L] Package Pinout by Location

6.9 IQX160 [PQFP/208L] Package Pinout

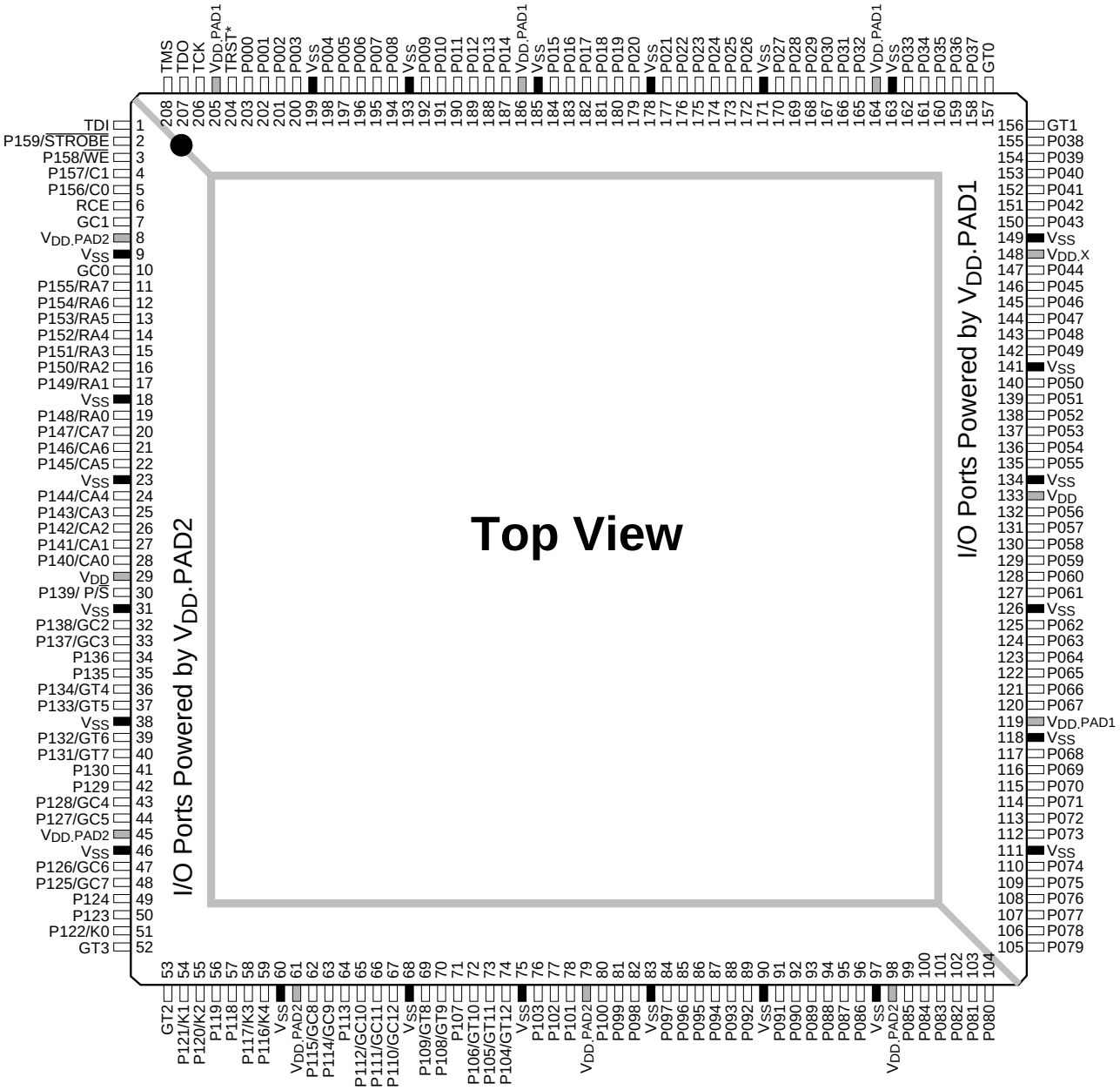

Figure 32. IQX160 [PQFP/208L] Package Pinout

6.10 IQX128B [PQFP/184L] Package Pinout by Name

Name	Pin#	Name	Pin#	Name	Pin#	Name	Pin#
GC0	10	P040	123	P086/GT10	63	TMS	184
GC1	7	P041	122	P087/GT9	62	TRST*	179
GT0	139	P042	121	P088/GT8	61	V_{DD}	28
GT1	138	P043	120	P089/GC12	58	V_{DD}	118
GT2	48	P044	117	P090/GC11	57	V_{DD}.PAD1	146
GT3	45	P045	116	P091/GC10	56	V_{DD}.PAD1	93
P000	178	P046	115	P092/GC9	55	V_{DD}.PAD1	106
P001	177	P047	114	P093/GC8	54	V_{DD}.PAD1	137
P002	176	P048	113	P094/K4	52	V_{DD}.PAD1	157
P003	175	P049	111	P095/K3	51	V_{DD}.PAD1	168
P004	173	P050	110	P096/K2	50	V_{DD}.PAD1	180
P005	172	P051	109	P097/K1	49	V_{DD}.PAD2	47
P006	171	P052	108	P098/K0	44	V_{DD}.PAD2	8
P007	170	P053	107	P099/GC7	43	V_{DD}.PAD2	18
P008	169	P054	104	P100/GC6	42	V_{DD}.PAD2	40
P009	166	P055	103	P101/GC5	39	V_{DD}.PAD2	60
P010	165	P056	102	P102†/GC4	38	V_{DD}.PAD2	73
P011	164	P057	101	P103†/GT7	37	V_{DD}.PAD2	86
P012	163	P058	100	P104†/GT6	36	V_{DD}.X	131
P013	161	P059	98	P105†/GT5	34	V_{SS}	41
P014	160	P060	97	P106†/GT4	33	V_{SS}	9
P015	159	P061	96	P107†/GC3	32	V_{SS}	17
P016	158	P062	95	P108†/GC2	31	V_{SS}	22
P017	155	P063	94	P109†/P/$\overline{S}$	29	V_{SS}	30
P018	154	P064	92	P110/CA0	27	V_{SS}	35
P019	153	P065	90	P111/CA1	26	V_{SS}	46
P020	152	P066	89	P112/CA2	25	V_{SS}	53
P021	150	P067	88	P113/CA3	24	V_{SS}	59
P022	149	P068	87	P114/CA4	23	V_{SS}	66
P023	148	P069	84	P115/CA5	21	V_{SS}	72
P024	147	P070	83	P116/CA6	20	V_{SS}	79
P025	144	P071	82	P117/RA0	19	V_{SS}	85
P026	143	P072	81	P118/RA1	16	V_{SS}	91
P027	142	P073	80	P119/RA2	15	V_{SS}	99
P028	141	P074	78	P120/RA3	14	V_{SS}	105
P029	140	P075	77	P121/RA4	13	V_{SS}	112
P030	136	P076	76	P122/RA5	12	V_{SS}	119
P031	135	P077	75	P123/RA6	11	V_{SS}	125
P032	134	P078	74	P124/C0	5	V_{SS}	132
P033	133	P079	71	P125/C1	4	V_{SS}	145
P034	130	P080	70	P126/$\overline{WE}$	3	V_{SS}	151
P035	129	P081	69	P127/$\overline{STROBE}$	2	V_{SS}	156
P036	128	P082	68	RCE	6	V_{SS}	162
P037	127	P083	67	TCK	181	V_{SS}	167
P038	126	P084/GT12	65	TDI	1	V_{SS}	174
P039	124	P085/GT11	64	TDO	183	V_{SS}	182

Table 27. IQX128B [PQFP/184L] Package Pinout by Name

6.11 IQX128B [PQFP/184L] Package Pinout by Location

Pin#	Name	Pin#	Name	Pin#	Name	Pin#	Name
1	TDI	47	V_{DD}.PAD2	93	V_{DD}.PAD1	139	GT0
2	P127/$\overline{\text{STROBE}}$	48	GT2	94	P063	140	P029
3	P126/$\overline{\text{WE}}$	49	P097/K1	95	P062	141	P028
4	P125/C1	50	P096/K2	96	P061	142	P027
5	P124/C0	51	P095/K3	97	P060	143	P026
6	RCE	52	P094/K4	98	P059	144	P025
7	GC1	53	V_{SS}	99	V_{SS}	145	V_{SS}
8	V_{DD}.PAD2	54	P093/GC8	100	P058	146	V_{DD}.PAD1
9	V_{SS}	55	P092/GC9	101	P057	147	P024
10	GC0	56	P091/GC10	102	P056	148	P023
11	P123/RA6	57	P090/GC11	103	P055	149	P022
12	P122/RA5	58	P089/GC12	104	P054	150	P021
13	P121/RA4	59	V_{SS}	105	V_{SS}	151	V_{SS}
14	P120/RA3	60	V_{DD}.PAD2	106	V_{DD}.PAD1	152	P020
15	P119/RA2	61	P088/GT8	107	P053	153	P019
16	P118/RA1	62	P087/GT9	108	P052	154	P018
17	V_{SS}	63	P086/GT10	109	P051	155	P017
18	V_{DD}.PAD2	64	P085/GT11	110	P050	156	V_{SS}
19	P117/RA0	65	P084/GT12	111	P049	157	V_{DD}.PAD1
20	P116/CA6	66	V_{SS}	112	V_{SS}	158	P016
21	P115/CA5	67	P083	113	P048	159	P015
22	V_{SS}	68	P082	114	P047	160	P014
23	P114/CA4	69	P081	115	P046	161	P013
24	P113/CA3	70	P080	116	P045	162	V_{SS}
25	P112/CA2	71	P079	117	P044	163	P012
26	P111/CA1	72	V_{SS}	118	V_{DD}	164	P011
27	P110/CA0	73	V_{DD}.PAD2	119	V_{SS}	165	P010
28	V_{DD}	74	P078	120	P043	166	P009
29	P109†/P/$\overline{\text{S}}$	75	P077	121	P042	167	V_{SS}
30	V_{SS}	76	P076	122	P041	168	V_{DD}.PAD1
31	P108†/GC2	77	P075	123	P040	169	P008
32	P107†/GC3	78	P074	124	P039	170	P007
33	P106†/GT4	79	V_{SS}	125	V_{SS}	171	P006
34	P105†/GT5	80	P073	126	P038	172	P005
35	V_{SS}	81	P072	127	P037	173	P004
36	P104†/GT6	82	P071	128	P036	174	V_{SS}
37	P103†/GT7	83	P070	129	P035	175	P003
38	P102†/GC4	84	P069	130	P034	176	P002
39	P101/GC5	85	V_{SS}	131	V_{DD}.X	177	P001
40	V_{DD}.PAD2	86	V_{DD}.PAD2	132	V_{SS}	178	P000
41	V_{SS}	87	P068	133	P033	179	TRST*
42	P100/GC6	88	P067	134	P032	180	V_{DD}.PAD1
43	P099/GC7	89	P066	135	P031	181	TCK
44	P098/K0	90	P065	136	P030	182	V_{SS}
45	GT3	91	V_{SS}	137	V_{DD}.PAD1	183	TDO
46	V_{SS}	92	P064	138	GT1	184	TMS

Table 28. IQX128B [PQFP/184L] Package Pinout by Location

6.12 IQX128B [PQFP/184L] Package Pinout

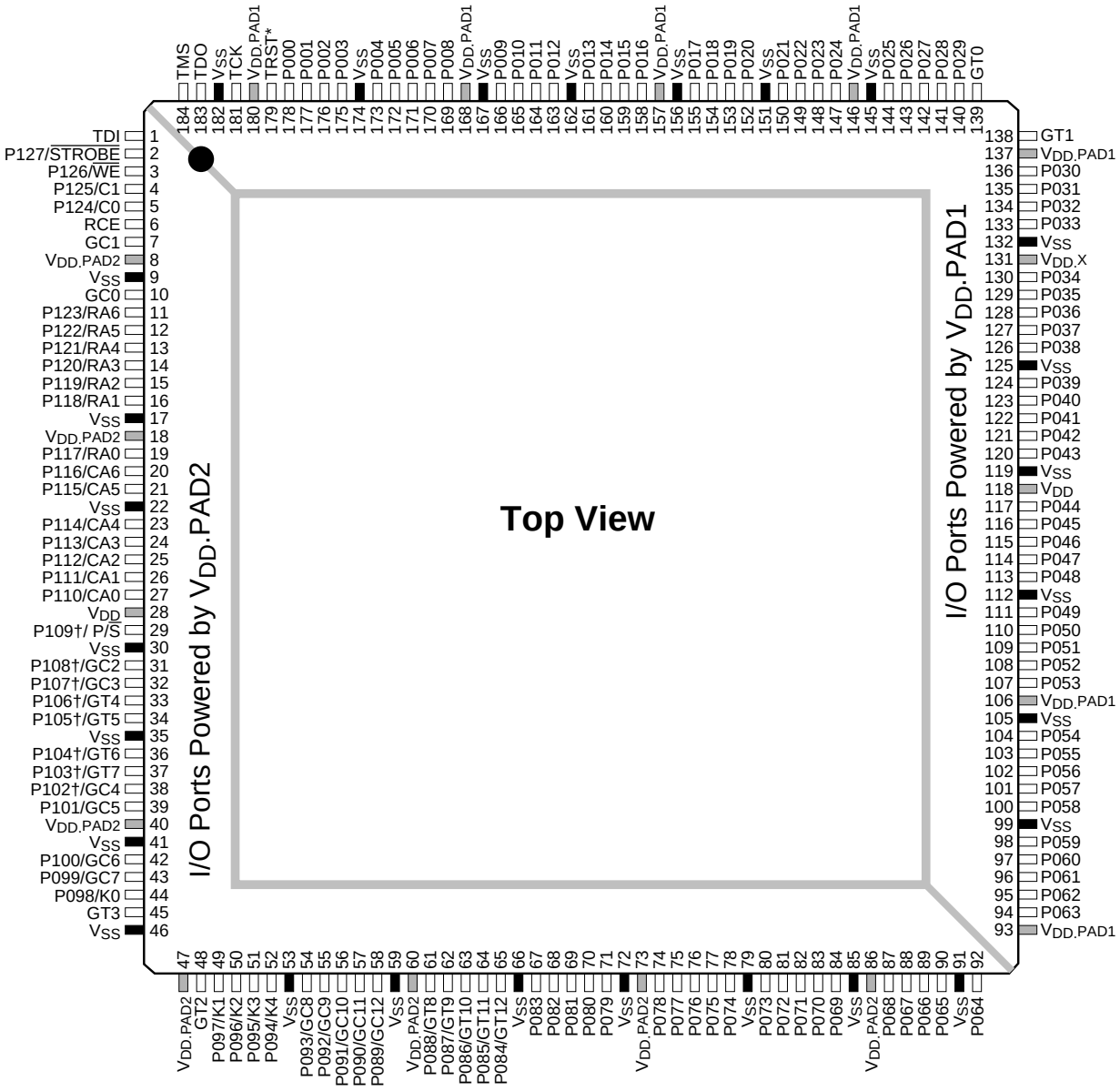

Figure 33. IQX128B [PQFP/184L] Package Pinout

7.0 MECHANICAL SPECIFICATION

7.1 IQX320 [PBGA/416L] Package Dimensions

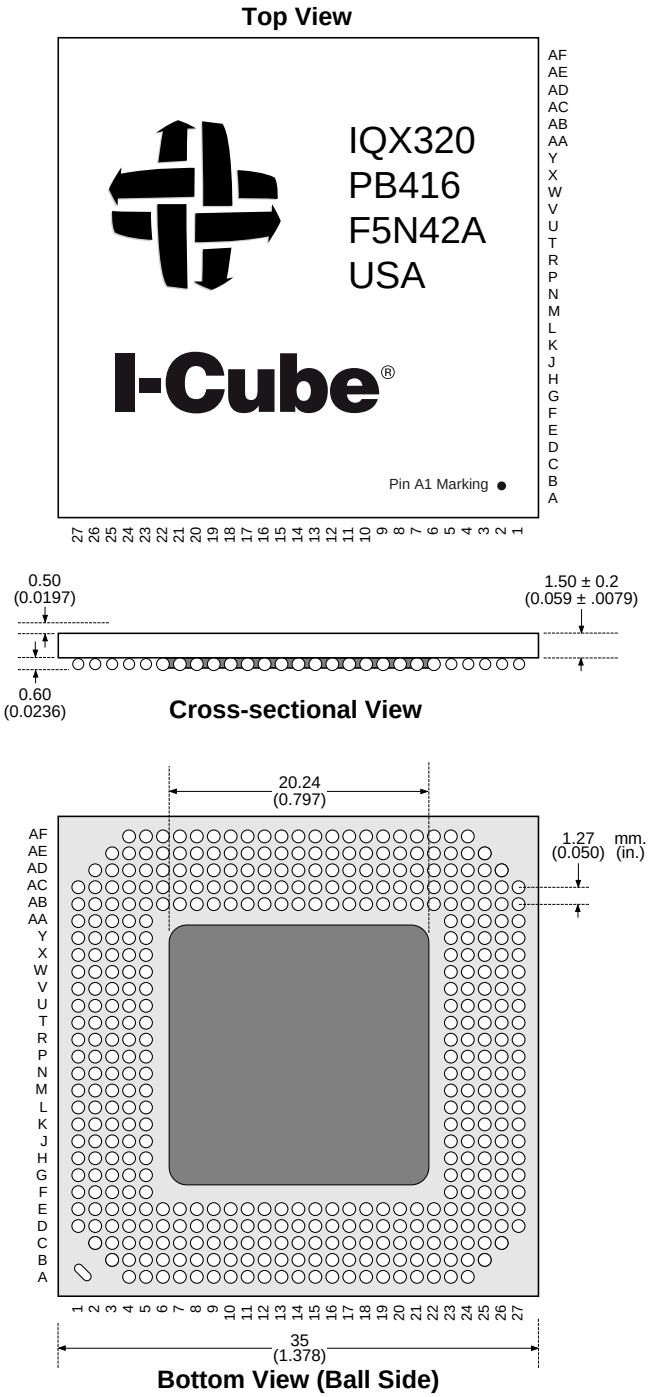

Figure 34. IQX320 [PBGA/416L] Package Dimensions

Note:

(1) Use “mm” as the controlling dimension.

7.2 PQFP Package Dimensions

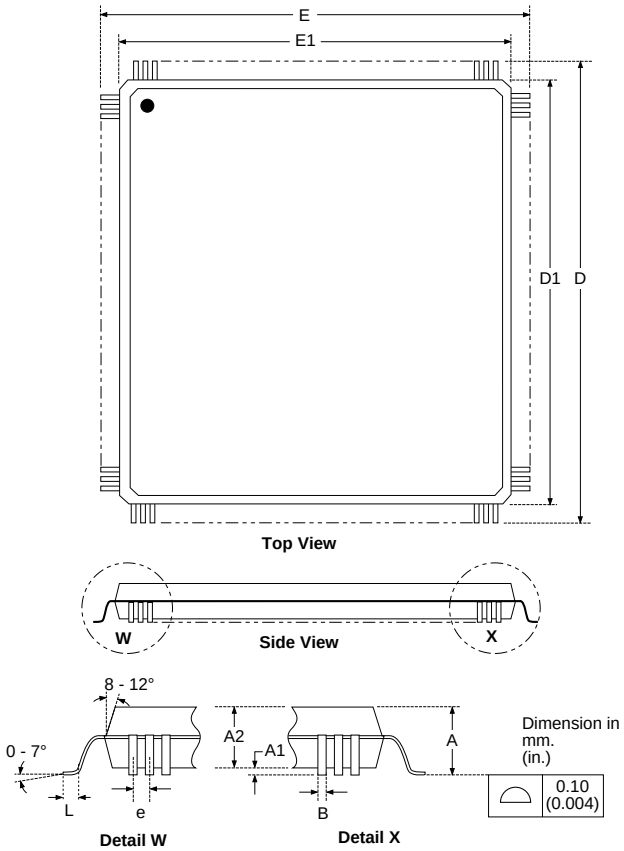

Figure 35. PQFP Package Dimensions

Note:

(1) Use “mm” as the controlling dimension

Package Dimension Table		PQFP/304L		PQFP/208L		PQFP/184L	
		inch	mm	inch	mm	inch	mm
A	max	0.172	4.37	0.157	3.99	0.157	3.99
A1	min	0.011	0.28	0.010	0.25	0.010	0.25
	max	0.019	0.47	0.017	0.43	0.017	0.43
A2	min	0.146	3.70	0.135	3.43	0.135	3.43
	max	0.154	3.90	0.140	3.56	0.140	3.56
D	min	1.669	42.40	1.195	30.40	1.219	31.01
	max	1.685	42.80	1.215	30.91	1.238	31.49
D1	min	1.571	39.90	1.098	27.93	1.098	27.93
	max	1.618	40.10	1.106	28.14	1.106	28.14
E	min	1.669	42.40	1.195	30.40	1.219	31.01
	max	1.685	42.80	1.215	30.91	1.238	31.49
E1	min	1.571	39.90	1.098	27.93	1.098	27.93
	max	1.618	40.10	1.106	28.14	1.106	28.14
L	min	0.020	0.50	0.018	0.46	0.029	0.74
	max	0.028	0.75	0.030	0.76	0.041	1.04
B	min	0.007	0.17	0.006	0.15	0.006	0.15
	max	0.011	0.27	0.011	0.28	0.011	0.28
e	BSC.	0.0197	0.50	0.0197	0.50	0.0197	0.50

Table 29. PQFP Package Dimensions

8.0 PACKAGE THERMAL CHARACTERISTICS

Package	Pin Count	Θ_{JC}(C/W)	Θ_{JA}(°C/W) Still Air	Θ_{JA}(°C/W) 200 lfpm	Θ_{JA}(°C/W) 400 lfpm	Θ_{JA}(°C/W) 600 lfpm
PQFP	184	6.6	37.4	28.3	24.2	21.7
	208	6.6	36.6	27.4	24.0	21.4
	304	6.3	21.6	19.3	17.9	16.3
PBGA	416	1.7	13.8	10.6	9.2	8.5

Table 30. Package Thermal Coefficients

Note:

(1) Thermal performance values are based on simulation data.

9.0 TABLES FOR DETERMINING DIE PAD TO I/O PORT PIN MAPPING AND LOCATIONS OF REAL SRAM CELL

The following tables help determine the locations of the real SRAM cells in the Switch Matrix. The SRAM cell controlling the connection between I/O Port “i” and I/O Port “j” is determined as follows:

Get the *Index* values corresponding to I/O Port numbers “i” and “j”. If the index value for “i” is greater than index value for “j”, then the SRAM cell has the row (word) address i* and column (bit) address j*, otherwise it has row address of j* and column address of i*. The numbers i* and j* represent the I/O Port locations on the die.

Ex 1: On the IQX160, the SRAM cell controlling the connection between I/O Port 20 and I/O Port 100 is at location: Row addr = 20, Col Addr = 100; because the index for I/O Port 20 is *82*, and it is greater than the index for I/O Port 100 which is *79*.

Ex 2: On the IQX240B, the SRAM cell controlling the connection between I/O Port 80 and I/O Port 180 is at location: Row addr = 241, Col Addr = 110; because the index value for I/O Port 80 is *120*, and it is less than the index value for I/O Port 180 which is *313*. Note that the IQX240B is a bondout version of IQX320 die, and the I/O Ports 80 and 180 on the device package are the I/O Ports *110* and *241* respectively.

Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index	Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index	Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index	Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index
0	-	2	40	30	162	80	-	0	120	90	160
1	0	6	41	31	166	81	60	4	121	91	164
2	-	10	42	32	170	82	-	8	122	92	168
3	1	14	43	33	174	83	61	12	123	93	172
4	-	18	44	34	178	84	-	16	124	94	176
5	2	22	45	35	182	85	62	20	125	95	180
6	-	26	46	36	186	86	-	24	126	96	184
7	3	30	47	37	190	87	63	28	127	97	188
8	-	34	48	38	194	88	-	32	128	98	192
9	4	38	49	39	198	89	64	36	129	99	196
10	-	42	50	40	202	90	-	40	130	100	200
11	5	46	51	41	206	91	65	44	131	101	204
12	-	50	52	42	210	92	-	48	132	102	208
13	6	54	53	43	214	93	66	52	133	103	212
14	-	58	54	44	218	94	67	56	134	104	216
15	7	62	55	45	222	95	68	60	135	105	220
16	8	66	56	-	226	96	-	64	136	106	224
17	9	70	57	46	230	97	69	68	137	107	228
18	10	74	58	-	234	98	-	72	138	108	232
19	11	78	59	47	238	99	70	76	139	109	236
20	12	82	60	-	242	100	-	80	140	-	240
21	13	86	61	48	246	101	71	84	141	110	244
22	14	90	62	-	250	102	72	88	142	-	248
23	15	94	63	49	254	103	73	92	143	111	252
24	-	98	64	-	258	104	74	96	144	-	256
25	16	102	65	50	262	105	75	100	145	112	260
26	17	106	66	-	266	106	76	104	146	-	264
27	18	110	67	51	270	107	77	108	147	113	268
28	19	114	68	-	274	108	78	112	148	-	272
29	20	118	69	52	278	109	79	116	149	114	276
30	21	122	70	-	282	110	80	120	150	-	280
31	22	126	71	53	286	111	81	124	151	115	284
32	23	130	72	-	290	112	82	128	152	-	288
33	24	134	73	54	294	113	83	132	153	116	292
34	-	138	74	-	298	114	84	136	154	-	296
35	25	142	75	55	302	115	85	140	155	117	300
36	26	146	76	56	306	116	86	144	156	-	304
37	27	150	77	57	310	117	87	148	157	118	308
38	28	154	78	58	314	118	88	152	158	-	312
39	29	158	79	59	318	119	89	156	159	119	316

Table 31. IQX320 and IQX240B I/O Port Pin Mapping

Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index	Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index	Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index	Die PAD and IQX320 I/O Port	IQX240B I/O Port	Index
160	-	319	200	149	159	240	-	317	280	-	157
161	120	315	201	150	155	241	180	313	281	208	153
162	-	311	202	151	151	242	181	309	282	-	149
163	121	307	203	152	147	243	182	305	283	209	145
164	-	303	204	153	143	244	-	301	284	-	141
165	122	299	205	154	139	245	183	297	285	210	137
166	-	295	206	155	135	246	-	293	286	-	133
167	123	291	207	156	131	247	184	289	287	211	129
168	-	287	208	157	127	248	-	285	288	-	125
169	124	283	209	158	123	249	185	281	289	212	121
170	-	279	210	159	119	250	-	277	290	-	117
171	125	275	211	160	115	251	186	273	291	213	113
172	-	271	212	161	111	252	-	269	292	-	109
173	126	267	213	162	107	253	187	265	293	214	105
174	-	263	214	163	103	254	188	261	294	-	101
175	127	259	215	164	99	255	189	257	295	215	97
176	-	255	216	165	95	256	190	253	296	216	93
177	128	251	217	166	91	257	191	249	297	217	89
178	-	247	218	167	87	258	192	245	298	218	85
179	129	243	219	168	83	259	193	241	299	219	81
180	-	239	220	169	79	260	194	237	300	220	77
181	130	235	221	170	75	261	195	233	301	221	73
182	131	231	222	-	71	262	-	229	302	222	69
183	132	227	223	171	67	263	196	225	303	223	65
184	133	223	224	-	63	264	-	221	304	224	61
185	134	219	225	172	59	265	197	217	305	225	57
186	135	215	226	-	55	266	-	213	306	226	53
187	136	211	227	173	51	267	198	209	307	227	49
188	137	207	228	-	47	268	199	205	308	228	45
189	138	203	229	174	43	269	200	201	309	229	41
190	139	199	230	-	39	270	201	197	310	230	37
191	140	195	231	175	35	271	202	193	311	231	33
192	141	191	232	-	31	272	203	189	312	232	29
193	142	187	233	176	27	273	204	185	313	233	25
194	143	183	234	-	23	274	-	181	314	234	21
195	144	179	235	177	19	275	205	177	315	235	17
196	145	175	236	-	15	276	-	173	316	236	13
197	146	171	237	178	11	277	206	169	317	237	9
198	147	167	238	-	7	278	-	165	318	238	5
199	148	163	239	179	3	279	207	161	319	239	1

Table 31. IQX320 and IQX240B I/O Port Pin Mapping *(Continued)*

128B Port	Index	Die PAD and IQX160 I/O Port	IQX128B I/O Port	Index	Die PAD and IQX160 I/O Port	IQX128B I/O Port	Index	Die PAD and IQX160 I/O Port	IQX128B I/O Port	Index
0	2	40	-	0	80	64	159	120	96	157
1	6	41	-	4	81	65	155	121	97	153
2	10	42	32	8	82	66	151	122	98	149
3	14	43	33	12	83	-	147	123	-	145
4	18	44	34	16	84	67	143	124	-	141
5	22	45	35	20	85	68	139	125	99	137
6	26	46	36	24	86	69	135	126	100	133
7	30	47	-	28	87	70	131	127	101	129
8	34	48	37	32	88	71	127	128	102	125
9	38	49	38	36	89	-	123	129	-	121
10	42	50	39	40	90	72	119	130	-	117
-	46	51	40	44	91	73	115	131	103	113
-	50	52	41	48	92	74	111	132	104	109
11	54	53	-	52	93	75	107	133	105	105
12	58	54	42	56	94	76	103	134	106	101
13	62	55	43	60	95	-	99	135	-	97
14	66	56	44	64	96	77	95	136	-	93
-	70	57	45	68	97	78	91	137	107	89
-	74	58	46	72	98	79	87	138	108	85
15	78	59	-	76	99	80	83	139	109	81
16	82	60	47	80	100	81	79	140	110	77
17	86	61	48	84	101	-	75	141	111	73
18	90	62	49	88	102	82	71	142	112	69
-	94	63	50	92	103	83	67	143	113	65
-	98	64	51	96	104	84	63	144	114	61
19	102	65	-	100	105	85	59	145	115	57
20	106	66	52	104	106	86	55	146	116	53
21	110	67	53	108	107	-	51	147	-	49
22	114	68	54	112	108	87	47	148	117	45
-	118	69	55	116	109	88	43	149	118	41
-	122	70	56	120	110	89	39	150	119	37
23	126	71	-	124	111	90	35	151	120	33
24	130	72	57	128	112	91	31	152	121	29
25	134	73	58	132	113	-	27	153	122	25
26	138	74	59	136	114	92	23	154	123	21
27	142	75	60	140	115	93	19	155	-	17
28	146	76	61	144	116	94	15	156	124	13
29	150	77	62	148	117	95	11	157	125	9
30	154	78	63	152	118	-	7	158	126	5
31	158	79	-	156	119	-	3	159	127	1

Table 32. IQX160 and IQX128B I/O Port Pin Mapping

10.0 Component Availability and Ordering Information

The following table lists the IQX devices and the different package options, and speed grades available.

Package	Pins	184	208	304	416
	Type	PQFP	PQFP	PQFP	PBGA
	Code	PQ184	PQ208	PQ304	PB416
IQX320	-12				X
	-10				X
IQX240B	-12			X	
	-10			X	
IQX160	-10		X		
	-7		X		
IQX128B	-10	X			
	-7	X			

Table 33. Component Availability

Device	Speed	Package*	Ordering#
IQX320	-12	PB 416	IQX320-PB416
	-10	PB 416	IQX320-10PB416
IQX240B	-12	PQ 304	IQX240B-PQ304
	-10	PQ 304	IQX240B-10PQ304
IQX160	-10	PQ 208	IQX160-PQ208
	-7	PQ 208	IQX160-7PQ208
IQX128B	-10	PQ 184	IQX128B-PQ184
	-7	PQ 184	IQX128B-7PQ184

Table 34. Ordering Information

* PB=Plastic Ball Grid Array, PQ=Plastic Quad Flat Pack

11.0 IQX FAMILY AT A GLANCE

Feature	IQX320	IQX240B	IQX160	IQX128B
Number of Usable I/O Port Pins	320	240	160	128
Switch Matrix Size	320 lines	240 lines	160 lines	128 lines
Programmable I/O Port Attributes				
Signal Direction	IN, OUT, BIDIR	IN, OUT, BIDIR	IN, OUT, BIDIR	IN, OUT, BIDIR
Dataflow	Flow-through, Latched, Clocked	Flow-through, Latched, Clocked	Flow-through, Latched, Clocked	Flow-through, Latched, Clocked
Control Signals	Clock, Clock Enable, Input Tristate, Output Tristate	Clock, Clock Enable, Input Tristate, Output Tristate	Clock, Clock Enable, Input Tristate, Output Tristate	Clock, Clock Enable, Input Tristate, Output Tristate
Number of Clock Control Pins				
dedicated	4	4	2	2
shared with I/O Port Pins	9	9	11	11
Number of Tristate Control Pins				
dedicated	5	5	4	4
shared with I/O Port Pins	8	8	9	9
I/O Ports Used By RapidConfigure Interface	23 / 22	23 / 22	21/20	19/18
Pin-to-Pin Delay	7.5 ns	7.5 ns	7.5 ns	7.5 ns
NRZ Data Rate	180 Mbs	180 Mbs	200 Mbs	200 Mbs
Maximum Clock Frequency	133 MHz	133 MHz	133 MHz	133 MHz
I/O Current Drive	12 mA	12 mA	12 mA	12 mA
I/O Voltage	3V and/or 5V	3V and/or 5V	3V and/or 5V	3V and/or 5V
Process	0.6µ	0.6µ	0.6µ	0.6µ
Packages	391 PPGA 416 PBGA	304 PQFP 304 MQUAD	208 PQFP 208 MQUAD	184 PQFP 184 MQUAD

Table 35. IQX Family at a Glance

12.0 PRODUCT STATUS DEFINITIONS

Data Sheet Identification	Product Status	Definition
Advanced	Formative or In Design	This data sheet contains the design specifications for product development. Specification may change in any manner without notice.
Preliminary	Preproduction Product	This data sheet contains the preliminary data, and supplementary data will be published at a later date. I-Cube reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
No Identification	Full Production	This data sheet contains final specifications. I-Cube reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
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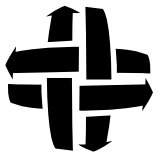
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