MAX 10 FPGA Device Overview

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MAX® 10 devices are the industry's first single chip, non-volatile programmable logic devices (PLDs) to integrate the optimal set of system components.

The following lists the highlights of the MAX 10 devices:

- Internally stored dual images with self-configuration
- Comprehensive design protection features
- Integrated ADCs
- Hardware to implement the Nios II 32-bit microcontroller IP

MAX 10 devices are the ideal solution for system management, I/O expansion, communication control planes, industrial, automotive, and consumer applications.

Related Information

MAX 10 FPGA Device Datasheet

Key Advantages of MAX 10 Devices

Table 1: Key Advantages of the MAX 10 Device Family

Advantage	Supporting Feature
Simple and fast configuration	Secure on-die configuration in less than 10 ms
Flexibility and integration	• Single device integrating PLD logic, RAM, flash memory, digital signal processing (DSP), ADC, phase-locked loop (PLL), and I/Os • Small packages available from 3 mm x 3 mm
Low power	• Sleep mode — significant standby power reduction and resume in less than 1 ms • Longer battery life — resume from full power-off in less than 10 ms
20 years estimated life cycle	Built on TSMC's 55 nm process technology

Advantage	Supporting Feature
High productivity design tools	• Quartus® II web edition • Qsys system integration tool • DSP Builder • Nios® II Embedded Design Suite (EDS)

Summary of MAX 10 Device Features

Table 2: Summary of Features for MAX 10 Devices

Feature	Description
Technology	55 nm TSMC Embedded Flash (EmbFlash) process technology
Packaging	• Low cost and small package sizes • Multiple device densities with compatible package footprints for seamless migration between different device densities • RoHS6-compliant
Core architecture	• 4-input look-up table (LUT) and single register logic element (LE) • LEs arranged in logic array block (LAB) • Embedded RAM and user flash memory • Clocks and PLLs • Embedded multiplier blocks • General purpose I/Os
Internal memory blocks	• M9K—9 kilobits (Kb) memory blocks • Cascadable blocks to create RAM, dual port, and FIFO functions
User Flash Memory	• User accessible non-volatile storage • High speed operating frequency • Large memory size • High data retention • Multiple interface option

Feature		Description
Embedded hard IP	Embedded multiplier blocks	• Support for one 18 x 18 or two 9 x 9 multiplier modes • Cascadable blocks enabling creation of filters, arithmetic functions, and image processing pipelines
	ADC	• 12-bits successive approximation register (SAR) type • Up to 17 analog inputs • Cumulative speed up to 1 million samples per second (MSPS) • Integrated temperature sensing capability
	Flash memory IP	Support for dual-boot self-configuration technology
Clock networks		• Support for global clocks • High speed frequency in clock network
Internal Oscillator		Built-in internal ring oscillator
PLLs		• Analog-based • Low jitter • High precision clock synthesis • Clock delay compensation • Zero delay buffering • Multiple output taps
General-purpose I/Os (GPIOs)		• Support multiple I/O standards • On-chip termination (OCT) • Up to 830 megabits per second (Mbps) LVDS receiver, 800 Mbps LVDS transmitter
External memory interface		Supports up to 600 Mbps external memory interfaces: • DDR3, DDR3L, DDR2, LPDDR2 (Only for 10M16, 10M25, 10M40, and 10M50). • SRAM (Hardware support only. Use your own design to interface with SRAM devices.)
Configuration		• Internal configuration • JTAG • Advanced Encryption Standard (AES) 128-bit encryption and compression options • Flash memory data retention of 10 years
Flexible power supply schemes		• Single and dual supply device options • Dynamically controlled input buffer power down • Sleep mode for dynamic power reduction

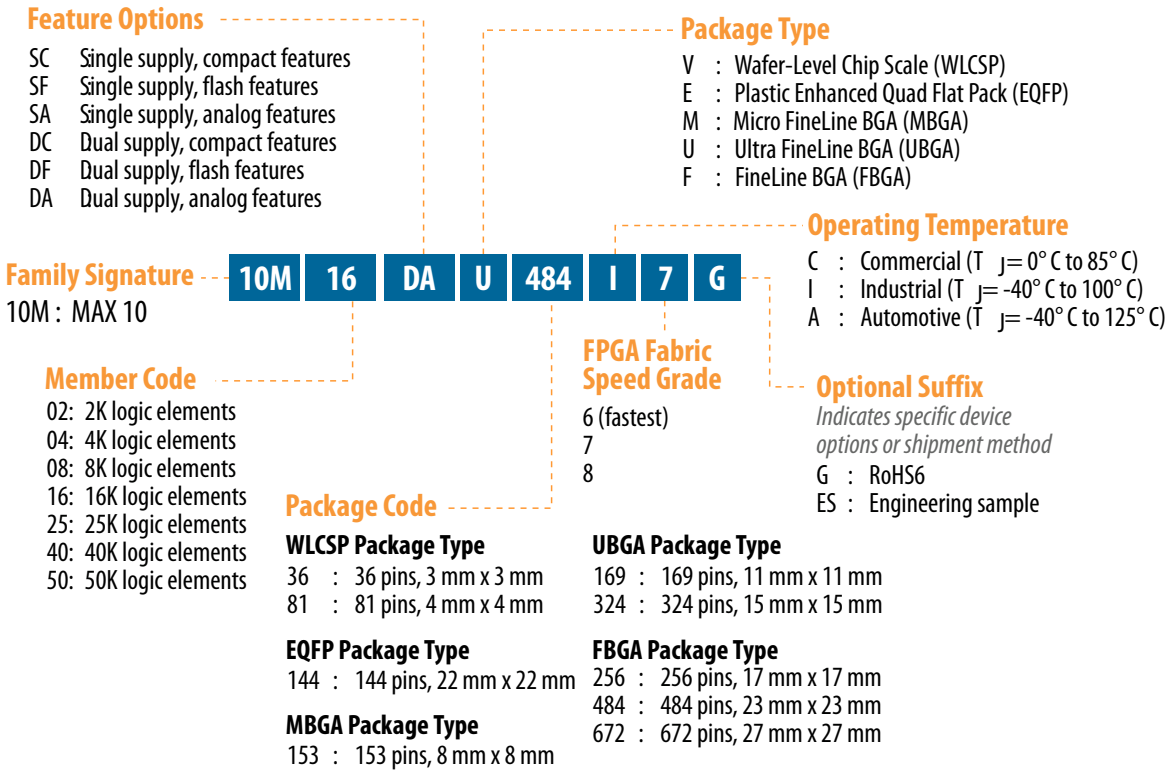
MAX 10 Device Feature Options

Table 3: Feature Options for MAX 10 Devices

Option	Feature
Compact	Devices with core architecture featuring single-boot self-configuration capability
Flash	Devices with core architecture featuring: • Dual-image self-configuration • Remote system upgrade capability
Analog	Devices with core architecture featuring: • Dual-image self-configuration • Remote system upgrade capability • Integrated analog-to-digital converter

MAX 10 Device Ordering Information

Figure 1: Sample Ordering Code and Available Options for MAX 10 Devices - Preliminary



Note: The –I6 speed grade MAX 10 FPGA device option is not available by default in the Quartus II software. Contact your local Altera sales representatives for support.

Related Information

Altera Product Selector
Provides the latest information about Altera products.

MAX 10 Device Maximum Resources

Table 4: Maximum Resource Counts for MAX 10 Devices—Preliminary

Resource		Device						
		10M02	10M04	10M08	10M16	10M25	10M40	10M50
Logic Elements (LE) (K)		2	4	8	16	25	40	50
M9K Memory (Kb)		108	189	378	549	675	1,260	1,638
Flash Memory (Kb) (1)		96	1,248	1,376	2,368	3,200	5,888	5,888
18 x 18 Multiplier		16	20	24	45	55	125	144
PLL		2	2	2	4	4	4	4
GPIO		160	246	250	320	380	500	500
LVDS	Dedicated Transmitter	10	15	15	22	26	30	30
	Emulated Transmitter	73	114	116	151	181	241	241
	Dedicated Receiver	73	114	116	151	181	241	241
Internal Configuration Image		1	2	2	2	2	2	2
ADC		—	1	1	1	2	2	2

MAX 10 Devices I/O Resources Per Package

Table 5: Package Plan for MAX 10 Single Power Supply Devices—Preliminary

Device	Package			
	Type	M153 153-pin MBGA	U169 169-pin UBGA	E144 144-pin EQFP
	Size	8 mm × 8 mm	11 mm × 11 mm	22 mm × 22 mm
	Ball Pitch	0.5 mm	0.8 mm	0.5 mm
10M02		112	130	101

(1) The flash memory capacities include user flash memory and configuration flash memory. For more information, refer to **MAX 10 User Flash Memory User Guide**.

Device	Package			
	Type	M153 153-pin MBGA	U169 169-pin UBGA	E144 144-pin EQFP
	Size	8 mm × 8 mm	11 mm × 11 mm	22 mm × 22 mm
	Ball Pitch	0.5 mm	0.8 mm	0.5 mm
10M04		112	130	101
10M08		112	130	101
10M16		—	130	101
10M25		—	—	101
10M40		—	—	101
10M50		—	—	101

Table 6: Package Plan for MAX 10 Dual Power Supply Devices—Preliminary

Device	Package						
	Type	V36 36-pin WLCSP	V81 81-pin WLCSP	U324 324-pin UBGA	F256 256-pin FBGA	F484 484-pin FBGA	F672 672-pin FBGA
	Size	3 mm × 3 mm	4 mm × 4 mm	15 mm × 15 mm	17 mm × 17 mm	23 mm × 23 mm	27 mm × 27 mm
	Ball Pitch	0.4 mm	0.4 mm	0.8 mm	1.0 mm	1.0 mm	1.0 mm
10M02		27	—	160	—	—	—
10M04		—	—	246	178	—	—
10M08		—	56	246	178	250	—
10M16		—	—	246	178	320	—
10M25		—	—	—	178	360	380
10M40		—	—	—	178	360	500
10M50		—	—	—	178	360	500

Related Information

MAX 10 General Purpose I/O User Guide

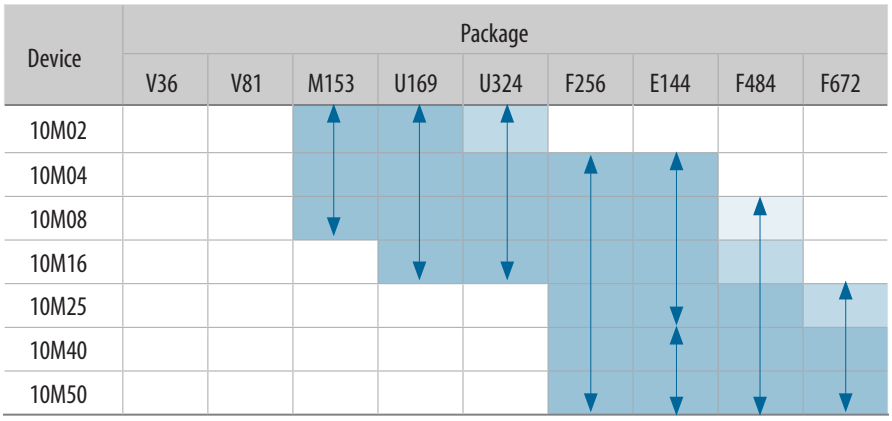
MAX 10 Vertical Migration Support

Vertical migration supports the migration of your design to other MAX 10 devices of different densities in the same package with similar I/O and ADC resources.

MAX 10 I/O Vertical Migration Support

Figure 2: Migration Capability Across MAX 10 Devices—Preliminary

- The arrows indicate the migration paths. The devices included in each vertical migration path are shaded. Some packages have several migration paths. Devices with lesser I/O resources in the same path have lighter shades.
- To achieve the full I/O migration across product lines in the same migration path, restrict I/Os usage to match the product line with the lowest I/O count.



Note: To verify the pin migration compatibility, use the Pin Migration View window in the Quartus II software Pin Planner.

MAX 10 ADC Vertical Migration Support

Figure 3: ADC Vertical Migration Across MAX 10 Devices—Preliminary

The arrows indicate the ADC migration paths. The devices included in each vertical migration path are shaded.

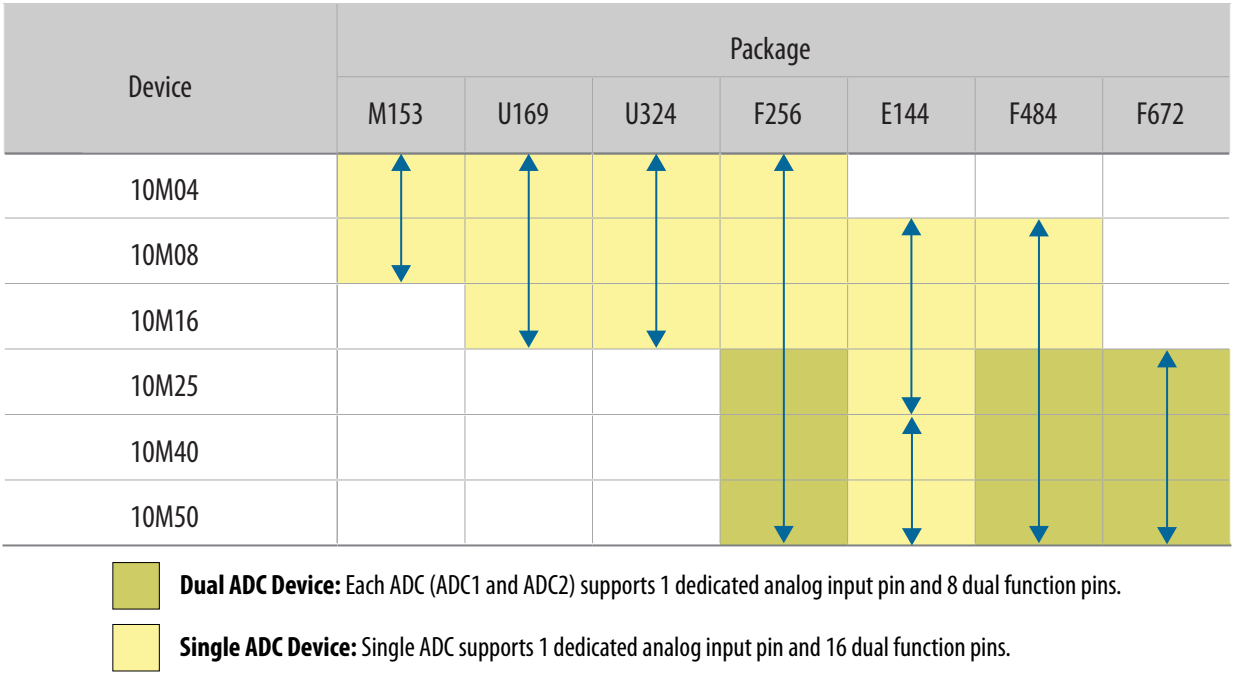


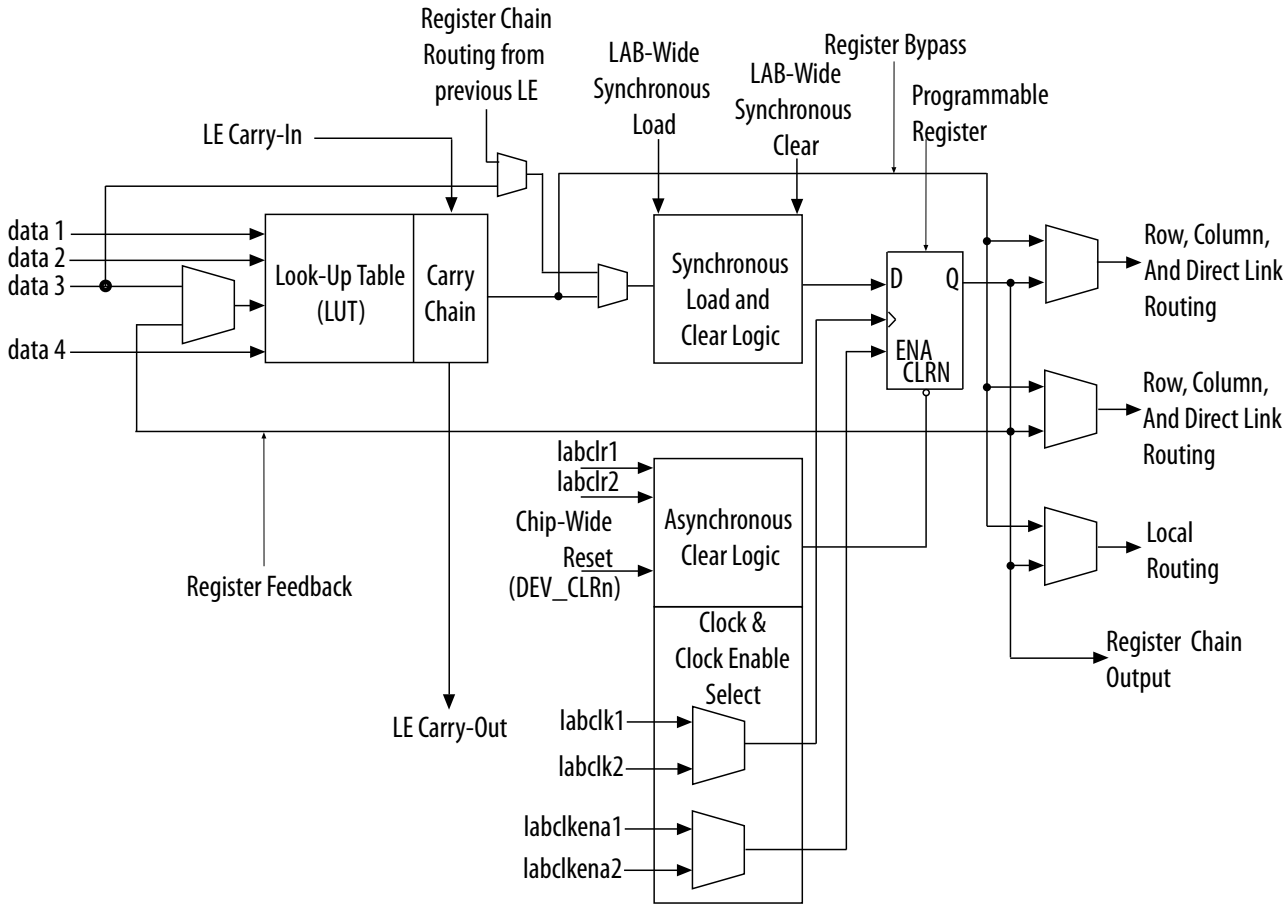
Table 7: Pin Migration Conditions for ADC Migration

Source	Target	Migratable Pins
Single ADC device	Single ADC device	You can migrate all ADC input pins
Dual ADC device	Dual ADC device	
Single ADC device	Dual ADC device	• One dedicated analog input pin. • Eight dual function pins from the ADC1 block of the source device to the ADC1 block of the target device.
Dual ADC device	Single ADC device	

Logic Elements and Logic Array Blocks

The LAB consists of 16 logic elements and a LAB-wide control block. An LE is the smallest unit of logic in the MAX 10 device architecture. Each LE has four inputs, a four-input look-up table (LUT), a register, and output logic. The four-input LUT is a function generator that can implement any function with four variables.

Figure 4: MAX 10 Device Family LEs



Analog-to-Digital Converter

MAX 10 devices feature up to two analog-to-digital converters (ADC). The ADCs of the MAX 10 devices monitor the internal temperature of the die and support external analog signal conversion.

Table 8: ADC Features

Feature	Description
12 bits resolution	• Translates analog quantities to digital data for information processing, computing, data transmission, and control systems • Provides a 12 bit digital representation of the observed analog signal
Up to 1 MSPS sampling rate	Monitors single-ended external inputs with a cumulative sampling rate of 1 MSPS in normal mode

Feature	Description
Up to 17 single-ended external inputs for single ADC devices	One dedicated analog and 16 dual function input pins
Up to 18 single-ended external inputs for dual ADC devices	• One dedicated analog and eight dual function input pins in each ADC block • Simultaneous measurement capability for dual ADC devices
On-chip temperature sensor	Monitors external temperature data input with a sampling rate of up to 50 kilosamples per second

User Flash Memory

The user flash memory (UFM) block in MAX 10 devices stores non-volatile information.

The UFM provides an ideal storage solution that you can access using the following protocols:

- Avalon Memory Mapped (Avalon-MM) slave interface to UFM
- SPI slave interface through Avalon-MM to UFM (available in version 14.1 of the Quartus II software onwards)

Table 9: UFM Features

Features	Capacity
Endurance	Up to 10,000 times read and write cycle counts
Operating frequency	Maximum 116 MHz
Data length storage	Up to 32-bit length

Embedded Multipliers and Digital Signal Processing Support

MAX 10 devices support up to 144 embedded multiplier blocks. Each block supports one individual 18 × 18-bit multiplier or two individual 9 × 9-bit multipliers.

In addition to embedded multipliers, the MAX 10 device includes a combination of on-chip resources and external interfaces to increase performance, reduce system cost, and lower the power consumption of digital signal processing (DSP) systems. You can use the MAX 10 device on its own or as a DSP device co-processor to improve price-to-performance ratios of DSP systems.

You can control the operation of the embedded multiplier blocks using the following options:

- Parameterize relevant IP cores with the Quartus II parameter editor
- Infer the multipliers directly with VHDL or Verilog

System design features provided for MAX 10 devices:

- DSP IP cores:
  - Common DSP processing functions such as finite impulse response (FIR), fast Fourier transform (FFT), and numerically controlled oscillator (NCO) functions
  - Suites of common video and image processing functions
- Complete reference designs for end-market applications
- DSP Builder interface tool between the Quartus II software and the MathWorks Simulink and MATLAB design environments
- DSP development kits

Embedded Memory Blocks

Each M9K memory block of the MAX 10 device provides 9 Kb of on-chip memory capable of operating at up to 284 MHz. The embedded memory structure consists of M9K memory blocks columns. You can configure the columns of the embedded M9K memory blocks as either one of the following:

- RAM
- First-in first-out (FIFO) buffers
- ROM

The MAX 10 device memory blocks are optimized for applications such as high throughput packet processing, embedded processor program, and embedded data storage.

You can utilize the M9K memory blocks using the following options:

- Parameterize relevant IP cores with the Quartus II parameter editor
- Infer the multipliers directly with VHDL or Verilog

Table 10: M9K Supported Operation Modes and Configurations

M9K Operation Modes	Port Widths Configuration
Single-port	×1, ×2, ×4, ×8, ×9, ×16, ×18, ×32, and ×36
Simple dual-port	×1, ×2, ×4, ×8, ×9, ×16, ×18, ×32, and ×36
True dual-port	×1, ×2, ×4, ×8, ×9, ×16, and ×18

Clocking and PLL

MAX 10 devices support up to 20 global clock (GCLK) networks with operating frequency up to 450 MHz. The GCLK networks have high drive strength and low skew.

MAX 10 devices have built-in internal oscillator.

The high precision and low jitter PLLs have the following usages:

- Reduction in the number of oscillators required on the board
- Reduction in the device clock pins through multiple clock frequency synthesis from a single reference clock source
- Frequency synthesis
- On-chip clock de-skew
- Jitter attenuation
- Dynamic phase-shift
- Zero delay buffer
- Counters reconfiguration
- Bandwidth reconfiguration
- Programmable output duty cycle
- PLL cascading
- Reference clock switchover
- Driving of the ADC block

FPGA General Purpose I/O

The MAX 10 device I/O buffers support the following programmable features:

- Programmable current strength
- Programmable output slew-rate control
- Programmable IOE delay
- PCI clamp diode
- Programmable pre-emphasis
- Programmable emulated differential output
- Programmable dynamic power down
- Programmable bus hold
- Programmable weak pull up
- Programmable open drain

External Memory Interface

The MAX 10 devices feature one soft memory controller for DDR3, DDR3L, DDR2, and LPDDR2 SDRAM interfaces on the right side of the device. The external memory controller in MAX 10 devices supports 16 bit SDRAM components with error correction coding (ECC).

The external memory interface feature is available for dual supply MAX 10 devices only.

Table 11: External Memory Interface Performance

External Memory Interface[2]	I/O Standard	Maximum Width	Maximum Frequency (MHz)
DDR3 SDRAM	SSTL-15	16 bit + 8 bit ECC	303
DDR3L SDRAM	SSTL-135	16 bit + 8 bit ECC	303

(2) The device hardware supports SRAM. Use your own design to interface with SRAM devices.

External Memory Interface[2]	I/O Standard	Maximum Width	Maximum Frequency (MHz)
DDR2 SDRAM	SSTL-18	16 bit + 8 bit ECC	200
LPDDR2 SDRAM	HSUL-12	16 bit without ECC	200

Note: MAX 10 FPGA support for the DDR3, DDR3L, DDR2, and LPDDR2 external memory interfaces is not available by default in the Quartus II software. Contact your local sales representative for support.

Related Information

External Memory Interface Spec Estimator
Provides a parametric tool that allows you to find and compare the performance of the supported external memory interfaces in Altera devices.

Configuration

Table 12: Configuration Features

Feature	Description
Dual-image configuration	• Stores two configuration images in the configuration flash memory (CFM) • Selects the first configuration image to boot using the BOOT_SEL pin
Design security	• Supports 128 bit key with non-volatile key programming • Limits access of the JTAG instruction during power-up in the JTAG secure mode
SEU Mitigation[3]	• Auto-detects cyclic redundancy check (CRC) errors during configuration • Provides optional CRC error detection and identification in user mode.
Dual-purpose configuration pin	• Functions as configuration pins prior to user mode • Provides option to be used as configuration pins or user I/O pins in user mode
Configuration data compression	• Receives compressed configuration bitstream and decompresses the data in real-time during configuration • Reduces the configuration image size stored in the CFM

[2] The device hardware supports SRAM. Use your own design to interface with SRAM devices.
[3] The SEU mitigation feature for single supply devices is disabled by default in the Quartus II software. For more information and support, contact your local sales representative.

Feature	Description
Instant-on	Provides the fastest power-up mode for MAX 10 devices without any POR delay

Table 13: Configuration Modes for MAX 10 Devices

Configuration Mode	Compression	Encryption	Dual Image Configuration	Data Width
Internal Configuration	Yes	Yes	Yes	—
JTAG	—	—	—	1

Power Management

Table 14: Power Options

Power Options	Advantage
Single supply device option	Saves board space and costs
Dual supply device option	• Consumes less power than the single supply device option • Offers higher performance than the single supply device option
Power management controller scheme	• Reduces dynamic power consumption when certain applications are in standby mode • Provides a fast wake-up time of less than 1 ms.

Document Revision History for MAX 10 FPGA Device Overview

Date	Version	Changes
September 2014	2014.09.22	Initial release.