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## Understanding [Embedded - FPGAs \(Field Programmable Gate Array\)](#)

Embedded - FPGAs, or Field Programmable Gate Arrays, are advanced integrated circuits that offer unparalleled flexibility and performance for digital systems. Unlike traditional fixed-function logic devices, FPGAs can be programmed and reprogrammed to execute a wide array of logical operations, enabling customized functionality tailored to specific applications. This reprogrammability allows developers to iterate designs quickly and implement complex functions without the need for custom hardware.

## Applications of Embedded - FPGAs

The versatility of Embedded - FPGAs makes them indispensable in numerous fields. In telecommunications.

### Details

Product Status	Active
Number of LABs/CLBs	160
Number of Logic Elements/Cells	1280
Total RAM Bits	65536
Number of I/O	104
Number of Gates	-
Voltage - Supply	1.14V ~ 1.26V
Mounting Type	Surface Mount
Operating Temperature	-40°C ~ 100°C (TJ)
Package / Case	132-LFBGA, CSPBGA
Supplier Device Package	132-CSPBGA (8x8)
Purchase URL	<a href="https://www.e-xfl.com/product-detail/lattice-semiconductor/lcmx02-1200ze-2mg132i">https://www.e-xfl.com/product-detail/lattice-semiconductor/lcmx02-1200ze-2mg132i</a>

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## Introduction

The MachXO2 family of ultra low power, instant-on, non-volatile PLDs has six devices with densities ranging from 256 to 6864 Look-Up Tables (LUTs). In addition to LUT-based, low-cost programmable logic these devices feature Embedded Block RAM (EBR), Distributed RAM, User Flash Memory (UFM), Phase Locked Loops (PLLs), pre-engineered source synchronous I/O support, advanced configuration support including dual-boot capability and hardened versions of commonly used functions such as SPI controller, I<sup>2</sup>C controller and timer/counter. These features allow these devices to be used in low cost, high volume consumer and system applications.

The MachXO2 devices are designed on a 65 nm non-volatile low power process. The device architecture has several features such as programmable low swing differential I/Os and the ability to turn off I/O banks, on-chip PLLs and oscillators dynamically. These features help manage static and dynamic power consumption resulting in low static power for all members of the family.

The MachXO2 devices are available in two versions – ultra low power (ZE) and high performance (HC and HE) devices. The ultra low power devices are offered in three speed grades –1, –2 and –3, with –3 being the fastest. Similarly, the high-performance devices are offered in three speed grades: –4, –5 and –6, with –6 being the fastest. HC devices have an internal linear voltage regulator which supports external V<sub>CC</sub> supply voltages of 3.3 V or 2.5 V. ZE and HE devices only accept 1.2 V as the external V<sub>CC</sub> supply voltage. With the exception of power supply voltage all three types of devices (ZE, HC and HE) are functionally compatible and pin compatible with each other.

The MachXO2 PLDs are available in a broad range of advanced halogen-free packages ranging from the space saving 2.5 mm x 2.5 mm WLCSP to the 23 mm x 23 mm fpBGA. MachXO2 devices support density migration within the same package. Table 1-1 shows the LUT densities, package and I/O options, along with other key parameters.

The pre-engineered source synchronous logic implemented in the MachXO2 device family supports a broad range of interface standards, including LPDDR, DDR, DDR2 and 7:1 gearing for display I/Os.

The MachXO2 devices offer enhanced I/O features such as drive strength control, slew rate control, PCI compatibility, bus-keeper latches, pull-up resistors, pull-down resistors, open drain outputs and hot socketing. Pull-up, pull-down and bus-keeper features are controllable on a “per-pin” basis.

A user-programmable internal oscillator is included in MachXO2 devices. The clock output from this oscillator may be divided by the timer/counter for use as clock input in functions such as LED control, key-board scanner and similar state machines.

The MachXO2 devices also provide flexible, reliable and secure configuration from on-chip Flash memory. These devices can also configure themselves from external SPI Flash or be configured by an external master through the JTAG test access port or through the I<sup>2</sup>C port. Additionally, MachXO2 devices support dual-boot capability (using external Flash memory) and remote field upgrade (TransFR) capability.

Lattice provides a variety of design tools that allow complex designs to be efficiently implemented using the MachXO2 family of devices. Popular logic synthesis tools provide synthesis library support for MachXO2. Lattice design tools use the synthesis tool output along with the user-specified preferences and constraints to place and route the design in the MachXO2 device. These tools extract the timing from the routing and back-annotate it into the design for timing verification.

Lattice provides many pre-engineered IP (Intellectual Property) LatticeCORE™ modules, including a number of reference designs licensed free of charge, optimized for the MachXO2 PLD family. By using these configurable soft core IP cores as standardized blocks, users are free to concentrate on the unique aspects of their design, increasing their productivity.

## Modes of Operation

Each slice has up to four potential modes of operation: Logic, Ripple, RAM and ROM.

### Logic Mode

In this mode, the LUTs in each slice are configured as 4-input combinatorial lookup tables. A LUT4 can have 16 possible input combinations. Any four input logic functions can be generated by programming this lookup table. Since there are two LUT4s per slice, a LUT5 can be constructed within one slice. Larger look-up tables such as LUT6, LUT7 and LUT8 can be constructed by concatenating other slices. Note LUT8 requires more than four slices.

### Ripple Mode

Ripple mode supports the efficient implementation of small arithmetic functions. In Ripple mode, the following functions can be implemented by each slice:

- Addition 2-bit
- Subtraction 2-bit
- Add/subtract 2-bit using dynamic control
- Up counter 2-bit
- Down counter 2-bit
- Up/down counter with asynchronous clear
- Up/down counter with preload (sync)
- Ripple mode multiplier building block
- Multiplier support
- Comparator functions of A and B inputs
  - A greater-than-or-equal-to B
  - A not-equal-to B
  - A less-than-or-equal-to B

Ripple mode includes an optional configuration that performs arithmetic using fast carry chain methods. In this configuration (also referred to as CCU2 mode) two additional signals, Carry Generate and Carry Propagate, are generated on a per-slice basis to allow fast arithmetic functions to be constructed by concatenating slices.

### RAM Mode

In this mode, a 16x4-bit distributed single port RAM (SPR) can be constructed by using each LUT block in Slice 0 and Slice 1 as a 16x1-bit memory. Slice 2 is used to provide memory address and control signals.

MachXO2 devices support distributed memory initialization.

The Lattice design tools support the creation of a variety of different size memories. Where appropriate, the software will construct these using distributed memory primitives that represent the capabilities of the PFU. Table 2-3 shows the number of slices required to implement different distributed RAM primitives. For more information about using RAM in MachXO2 devices, please see TN1201, [Memory Usage Guide for MachXO2 Devices](#).

**Table 2-3. Number of Slices Required For Implementing Distributed RAM**

	SPR 16x4	PDPR 16x4
Number of slices	3	3

Note: SPR = Single Port RAM, PDPR = Pseudo Dual Port RAM

## PIO

The PIO contains three blocks: an input register block, output register block and tri-state register block. These blocks contain registers for operating in a variety of modes along with the necessary clock and selection logic.

**Table 2-8. PIO Signal List**

Pin Name	I/O Type	Description
CE	Input	Clock Enable
D	Input	Pin input from sysIO buffer.
INDD	Output	Register bypassed input.
INCK	Output	Clock input
Q0	Output	DDR positive edge input
Q1	Output	Registered input/DDR negative edge input
D0	Input	Output signal from the core (SDR and DDR)
D1	Input	Output signal from the core (DDR)
TD	Input	Tri-state signal from the core
Q	Output	Data output signals to sysIO Buffer
TQ	Output	Tri-state output signals to sysIO Buffer
DQSR90 <sup>1</sup>	Input	DQS shift 90-degree read clock
DQSW90 <sup>1</sup>	Input	DQS shift 90-degree write clock
DDRCLKPOL <sup>1</sup>	Input	DDR input register polarity control signal from DQS
SCLK	Input	System clock for input and output/tri-state blocks.
RST	Input	Local set reset signal

1. Available in PIO on right edge only.

### Input Register Block

The input register blocks for the PIOs on all edges contain delay elements and registers that can be used to condition high-speed interface signals before they are passed to the device core. In addition to this functionality, the input register blocks for the PIOs on the right edge include built-in logic to interface to DDR memory.

Figure 2-12 shows the input register block for the PIOs located on the left, top and bottom edges. Figure 2-13 shows the input register block for the PIOs on the right edge.

#### Left, Top, Bottom Edges

Input signals are fed from the sysIO buffer to the input register block (as signal D). If desired, the input signal can bypass the register and delay elements and be used directly as a combinatorial signal (INDD), and a clock (INCK). If an input delay is desired, users can select a fixed delay. I/Os on the bottom edge also have a dynamic delay, DEL[4:0]. The delay, if selected, reduces input register hold time requirements when using a global clock. The input block allows two modes of operation. In single data rate (SDR) the data is registered with the system clock (SCLK) by one of the registers in the single data rate sync register block. In Generic DDR mode, two registers are used to sample the data on the positive and negative edges of the system clock (SCLK) signal, creating two data streams.

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## DDR Memory Support

Certain PICs on the right edge of MachXO2-640U, MachXO2-1200/U and larger devices, have additional circuitry to allow the implementation of DDR memory interfaces. There are two groups of 14 or 12 PIOs each on the right edge with additional circuitry to implement DDR memory interfaces. This capability allows the implementation of up to 16-bit wide memory interfaces. One PIO from each group contains a control element, the DQS Read/Write Block, to facilitate the generation of clock and control signals (DQSR90, DQSW90, DDRCLKPOL and DATAVALID). These clock and control signals are distributed to the other PIO in the group through dedicated low skew routing.

### DQS Read Write Block

Source synchronous interfaces generally require the input clock to be adjusted in order to correctly capture data at the input register. For most interfaces a PLL is used for this adjustment. However, in DDR memories the clock (referred to as DQS) is not free-running so this approach cannot be used. The DQS Read Write block provides the required clock alignment for DDR memory interfaces. DQSR90 and DQSW90 signals are generated by the DQS Read Write block from the DQS input.

In a typical DDR memory interface design, the phase relationship between the incoming delayed DQS strobe and the internal system clock (during the read cycle) is unknown. The MachXO2 family contains dedicated circuits to transfer data between these domains. To prevent set-up and hold violations, at the domain transfer between DQS (delayed) and the system clock, a clock polarity selector is used. This circuit changes the edge on which the data is registered in the synchronizing registers in the input register block. This requires evaluation at the start of each read cycle for the correct clock polarity. Prior to the read operation in DDR memories, DQS is in tri-state (pulled by termination). The DDR memory device drives DQS low at the start of the preamble state. A dedicated circuit in the DQS Read Write block detects the first DQS rising edge after the preamble state and generates the DDRCLKPOL signal. This signal is used to control the polarity of the clock to the synchronizing registers.

The temperature, voltage and process variations of the DQS delay block are compensated by a set of calibration signals (6-bit bus) from a DLL on the right edge of the device. The DLL loop is compensated for temperature, voltage and process variations by the system clock and feedback loop.

### sysIO Buffer

Each I/O is associated with a flexible buffer referred to as a sysIO buffer. These buffers are arranged around the periphery of the device in groups referred to as banks. The sysIO buffers allow users to implement a wide variety of standards that are found in today's systems including LVCMOS, TTL, PCI, SSTL, HSTL, LVDS, BLVDS, MLVDS and LVPECL.

Each bank is capable of supporting multiple I/O standards. In the MachXO2 devices, single-ended output buffers, ratioed input buffers (LVTTL, LVCMOS and PCI), differential (LVDS) and referenced input buffers (SSTL and HSTL) are powered using I/O supply voltage ( $V_{CCIO}$ ). Each sysIO bank has its own  $V_{CCIO}$ . In addition, each bank has a voltage reference,  $V_{REF}$  which allows the use of referenced input buffers independent of the bank  $V_{CCIO}$ .

MachXO2-256 and MachXO2-640 devices contain single-ended ratioed input buffers and single-ended output buffers with complementary outputs on all the I/O banks. Note that the single-ended input buffers on these devices do not contain PCI clamps. In addition to the single-ended I/O buffers these two devices also have differential and referenced input buffers on all I/Os. The I/Os are arranged in pairs, the two pads in the pair are described as "T" and "C", where the true pad is associated with the positive side of the differential input buffer and the comp (complementary) pad is associated with the negative side of the differential input buffer.

MachXO2-640U, MachXO2-1200/U, MachXO2-2000/U, MachXO2-4000 and MachXO2-7000 devices contain three types of sysIO buffer pairs.

**1. Left and Right sysIO Buffer Pairs**

The sysIO buffer pairs in the left and right banks of the device consist of two single-ended output drivers and two single-ended input buffers (for ratioed inputs such as LVCMOS and LVTTL). The I/O pairs on the left and right of the devices also have differential and referenced input buffers.

**2. Bottom sysIO Buffer Pairs**

The sysIO buffer pairs in the bottom bank of the device consist of two single-ended output drivers and two single-ended input buffers (for ratioed inputs such as LVCMOS and LVTTL). The I/O pairs on the bottom also have differential and referenced input buffers. Only the I/Os on the bottom banks have programmable PCI clamps and differential input termination. The PCI clamp is enabled after  $V_{CC}$  and  $V_{CCIO}$  are at valid operating levels and the device has been configured.

**3. Top sysIO Buffer Pairs**

The sysIO buffer pairs in the top bank of the device consist of two single-ended output drivers and two single-ended input buffers (for ratioed inputs such as LVCMOS and LVTTL). The I/O pairs on the top also have differential and referenced I/O buffers. Half of the sysIO buffer pairs on the top edge have true differential outputs. The sysIO buffer pair comprising of the A and B PIOs in every PIC on the top edge have a differential output driver. The referenced input buffer can also be configured as a differential input buffer.

## Typical I/O Behavior During Power-up

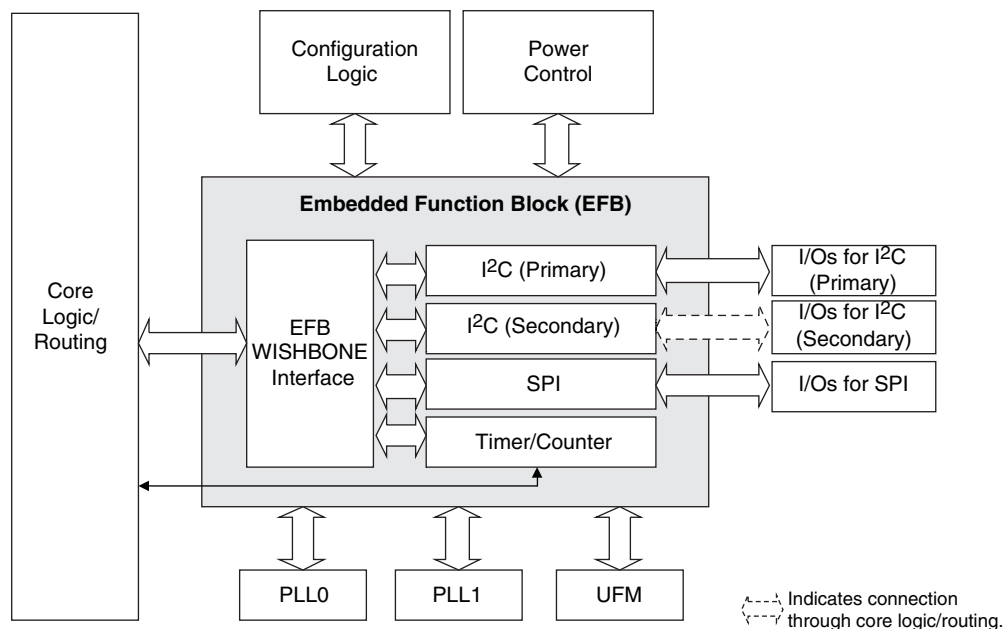
The internal power-on-reset (POR) signal is deactivated when  $V_{CC}$  and  $V_{CCIO0}$  have reached  $V_{PORUP}$  level defined in the Power-On-Reset Voltage table in the DC and Switching Characteristics section of this data sheet. After the POR signal is deactivated, the FPGA core logic becomes active. It is the user's responsibility to ensure that all  $V_{CCIO}$  banks are active with valid input logic levels to properly control the output logic states of all the I/O banks that are critical to the application. The default configuration of the I/O pins in a blank device is tri-state with a weak pull-down to GND (some pins such as PROGRAMN and the JTAG pins have weak pull-up to  $V_{CCIO}$  as the default functionality). The I/O pins will maintain the blank configuration until  $V_{CC}$  and  $V_{CCIO}$  (for I/O banks containing configuration I/Os) have reached  $V_{PORUP}$  levels at which time the I/Os will take on the user-configured settings only after a proper download/configuration.

## Supported Standards

The MachXO2 sysIO buffer supports both single-ended and differential standards. Single-ended standards can be further subdivided into LVCMOS, LVTTL, and PCI. The buffer supports the LVTTL, PCI, LVCMOS 1.2, 1.5, 1.8, 2.5, and 3.3 V standards. In the LVCMOS and LVTTL modes, the buffer has individually configurable options for drive strength, bus maintenance (weak pull-up, weak pull-down, bus-keeper latch or none) and open drain. BLVDS, MLVDS and LVPECL output emulation is supported on all devices. The MachXO2-640U, MachXO2-1200/U and higher devices support on-chip LVDS output buffers on approximately 50% of the I/Os on the top bank. Differential receivers for LVDS, BLVDS, MLVDS and LVPECL are supported on all banks of MachXO2 devices. PCI support is provided in the bottom bank of the MachXO2-640U, MachXO2-1200/U and higher density devices. Table 2-11 summarizes the I/O characteristics of the MachXO2 PLDs.

Tables 2-11 and 2-12 show the I/O standards (together with their supply and reference voltages) supported by the MachXO2 devices. For further information on utilizing the sysIO buffer to support a variety of standards please see TN1202, [MachXO2 sysIO Usage Guide](#).

**Figure 2-20. Embedded Function Block Interface**



## Hardened I<sup>2</sup>C IP Core

Every MachXO2 device contains two I<sup>2</sup>C IP cores. These are the primary and secondary I<sup>2</sup>C IP cores. Either of the two cores can be configured either as an I<sup>2</sup>C master or as an I<sup>2</sup>C slave. The only difference between the two IP cores is that the primary core has pre-assigned I/O pins whereas users can assign I/O pins for the secondary core.

When the IP core is configured as a master it will be able to control other devices on the I<sup>2</sup>C bus through the interface. When the core is configured as the slave, the device will be able to provide I/O expansion to an I<sup>2</sup>C Master. The I<sup>2</sup>C cores support the following functionality:

- Master and Slave operation
- 7-bit and 10-bit addressing
- Multi-master arbitration support
- Up to 400 kHz data transfer speed
- General call support
- Interface to custom logic through 8-bit WISHBONE interface

### DC Electrical Characteristics

#### Over Recommended Operating Conditions

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
$I_{IL}, I_{IH}^{1,4}$	Input or I/O Leakage	Clamp OFF and $V_{CCIO} < V_{IN} < V_{IH} (MAX)$	—	—	+175	$\mu A$
		Clamp OFF and $V_{IN} = V_{CCIO}$	-10	—	10	$\mu A$
		Clamp OFF and $V_{CCIO} - 0.97 V < V_{IN} < V_{CCIO}$	-175	—	—	$\mu A$
		Clamp OFF and $0 V < V_{IN} < V_{CCIO} - 0.97 V$	—	—	10	$\mu A$
		Clamp OFF and $V_{IN} = GND$	—	—	10	$\mu A$
		Clamp ON and $0 V < V_{IN} < V_{CCIO}$	—	—	10	$\mu A$
$I_{PU}$	I/O Active Pull-up Current	$0 < V_{IN} < 0.7 V_{CCIO}$	-30	—	-309	$\mu A$
$I_{PD}$	I/O Active Pull-down Current	$V_{IL} (MAX) < V_{IN} < V_{CCIO}$	30	—	305	$\mu A$
$I_{BHLS}$	Bus Hold Low sustaining current	$V_{IN} = V_{IL} (MAX)$	30	—	—	$\mu A$
$I_{BHHS}$	Bus Hold High sustaining current	$V_{IN} = 0.7 V_{CCIO}$	-30	—	—	$\mu A$
$I_{BHLO}$	Bus Hold Low Overdrive current	$0 \leq V_{IN} \leq V_{CCIO}$	—	—	305	$\mu A$
$I_{BHHO}$	Bus Hold High Overdrive current	$0 \leq V_{IN} \leq V_{CCIO}$	—	—	-309	$\mu A$
$V_{BHT}^3$	Bus Hold Trip Points		$V_{IL} (MAX)$	—	$V_{IH} (MIN)$	V
C1	I/O Capacitance <sup>2</sup>	$V_{CCIO} = 3.3 V, 2.5 V, 1.8 V, 1.5 V, 1.2 V, V_{CC} = Typ., V_{IO} = 0 \text{ to } V_{IH} (MAX)$	3	5	9	pF
C2	Dedicated Input Capacitance <sup>2</sup>	$V_{CCIO} = 3.3 V, 2.5 V, 1.8 V, 1.5 V, 1.2 V, V_{CC} = Typ., V_{IO} = 0 \text{ to } V_{IH} (MAX)$	3	5.5	7	pF
$V_{HYST}$	Hysteresis for Schmitt Trigger Inputs <sup>5</sup>	$V_{CCIO} = 3.3 V, \text{Hysteresis} = \text{Large}$	—	450	—	mV
		$V_{CCIO} = 2.5 V, \text{Hysteresis} = \text{Large}$	—	250	—	mV
		$V_{CCIO} = 1.8 V, \text{Hysteresis} = \text{Large}$	—	125	—	mV
		$V_{CCIO} = 1.5 V, \text{Hysteresis} = \text{Large}$	—	100	—	mV
		$V_{CCIO} = 3.3 V, \text{Hysteresis} = \text{Small}$	—	250	—	mV
		$V_{CCIO} = 2.5 V, \text{Hysteresis} = \text{Small}$	—	150	—	mV
		$V_{CCIO} = 1.8 V, \text{Hysteresis} = \text{Small}$	—	60	—	mV
		$V_{CCIO} = 1.5 V, \text{Hysteresis} = \text{Small}$	—	40	—	mV

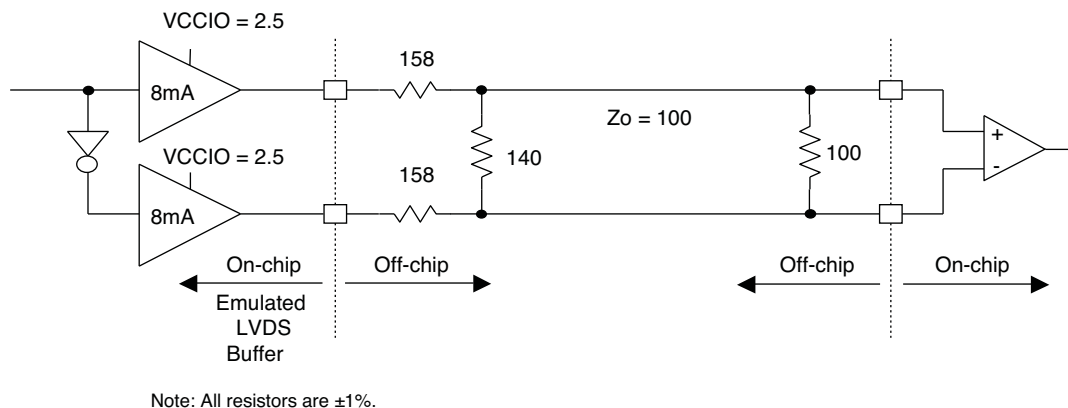
1. Input or I/O leakage current is measured with the pin configured as an input or as an I/O with the output driver tri-stated. It is not measured with the output driver active. Bus maintenance circuits are disabled.
2.  $T_A = 25^\circ C, f = 1.0 \text{ MHz}$ .
3. Please refer to  $V_{IL}$  and  $V_{IH}$  in the sysIO Single-Ended DC Electrical Characteristics table of this document.
4. When  $V_{IH}$  is higher than  $V_{CCIO}$ , a transient current typically of 30 ns in duration or less with a peak current of 6 mA can occur on the high-to-low transition. For true LVDS output pins in MachXO2-640U, MachXO2-1200/U and larger devices,  $V_{IH}$  must be less than or equal to  $V_{CCIO}$ .
5. With bus keeper circuit turned on. For more details, refer to TN1202, [MachXO2 sysIO Usage Guide](#).



### LVDS Emulation

MachXO2 devices can support LVDS outputs via emulation (LVDS25E). The output is emulated using complementary LVCMOS outputs in conjunction with resistors across the driver outputs on all devices. The scheme shown in Figure 3-1 is one possible solution for LVDS standard implementation. Resistor values in Figure 3-1 are industry standard values for 1% resistors.

**Figure 3-1. LVDS Using External Resistors (LVDS25E)**



**Table 3-1. LVDS25E DC Conditions**

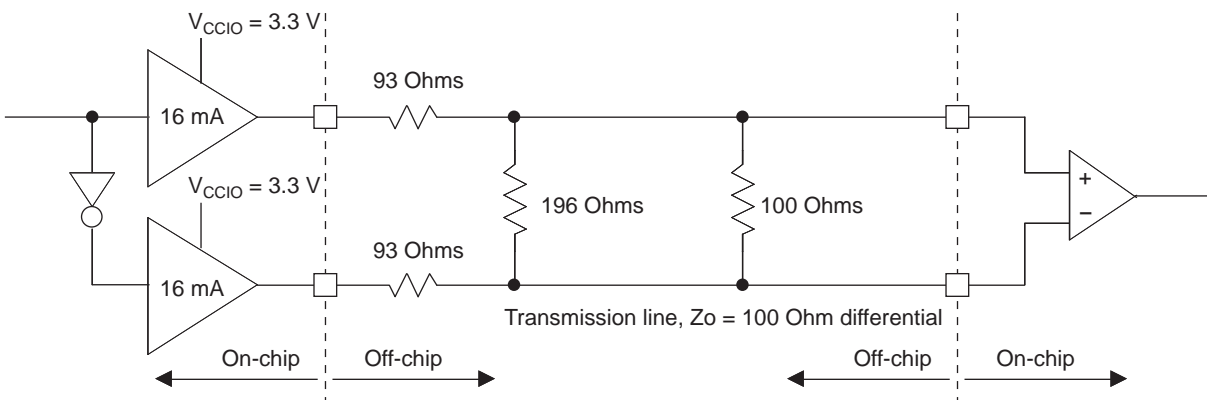
#### Over Recommended Operating Conditions

Parameter	Description	Typ.	Units
$Z_{OUT}$	Output impedance	20	Ohms
$R_S$	Driver series resistor	158	Ohms
$R_P$	Driver parallel resistor	140	Ohms
$R_T$	Receiver termination	100	Ohms
$V_{OH}$	Output high voltage	1.43	V
$V_{OL}$	Output low voltage	1.07	V
$V_{OD}$	Output differential voltage	0.35	V
$V_{CM}$	Output common mode voltage	1.25	V
$Z_{BACK}$	Back impedance	100.5	Ohms
$I_{DC}$	DC output current	6.03	mA

### LVPECL

The MachXO2 family supports the differential LVPECL standard through emulation. This output standard is emulated using complementary LVCMOS outputs in conjunction with resistors across the driver outputs on all the devices. The LVPECL input standard is supported by the LVDS differential input buffer. The scheme shown in Differential LVPECL is one possible solution for point-to-point signals.

**Figure 3-3. Differential LVPECL**



**Table 3-3. LVPECL DC Conditions<sup>1</sup>**

#### Over Recommended Operating Conditions

Symbol	Description	Nominal	Units
$Z_{OUT}$	Output impedance	20	Ohms
$R_S$	Driver series resistor	93	Ohms
$R_P$	Driver parallel resistor	196	Ohms
$R_T$	Receiver termination	100	Ohms
$V_{OH}$	Output high voltage	2.05	V
$V_{OL}$	Output low voltage	1.25	V
$V_{OD}$	Output differential voltage	0.80	V
$V_{CM}$	Output common mode voltage	1.65	V
$Z_{BACK}$	Back impedance	100.5	Ohms
$I_{DC}$	DC output current	12.11	mA

1. For input buffer, see LVDS table.

For further information on LVPECL, BLVDS and other differential interfaces please see details of additional technical documentation at the end of the data sheet.

Parameter	Description	Device	-6		-5		-4		Units
			Min.	Max.	Min.	Max.	Min.	Max.	
Generic DDR4 Inputs with Clock and Data Aligned at Pin Using PCLK Pin for Clock Input – GDDR4_RX.ECLK.Aligned <sup>9, 12</sup>									
t <sub>DVA</sub>	Input Data Valid After ECLK	MachXO2-640U, MachXO2-1200/U and larger devices, bottom side only. <sup>11</sup>	—	0.290	—	0.320	—	0.345	UI
t <sub>DVE</sub>	Input Data Hold After ECLK		0.739	—	0.699	—	0.703	—	UI
f <sub>DATA</sub>	DDR4 Serial Input Data Speed		—	756	—	630	—	524	Mbps
f <sub>DDR4</sub>	DDR4 ECLK Frequency		—	378	—	315	—	262	MHz
f <sub>SCLK</sub>	SCLK Frequency		—	95	—	79	—	66	MHz
Generic DDR4 Inputs with Clock and Data Centered at Pin Using PCLK Pin for Clock Input – GDDR4_RX.ECLK.Centered <sup>9, 12</sup>									
t <sub>SU</sub>	Input Data Setup Before ECLK	MachXO2-640U, MachXO2-1200/U and larger devices, bottom side only. <sup>11</sup>	0.233	—	0.219	—	0.198	—	ns
t <sub>HO</sub>	Input Data Hold After ECLK		0.287	—	0.287	—	0.344	—	ns
f <sub>DATA</sub>	DDR4 Serial Input Data Speed		—	756	—	630	—	524	Mbps
f <sub>DDR4</sub>	DDR4 ECLK Frequency		—	378	—	315	—	262	MHz
f <sub>SCLK</sub>	SCLK Frequency		—	95	—	79	—	66	MHz
7:1 LVDS Inputs (GDDR71_RX.ECLK.7:1) <sup>9, 12</sup>									
t <sub>DVA</sub>	Input Data Valid After ECLK	MachXO2-640U, MachXO2-1200/U and larger devices, bottom side only. <sup>11</sup>	—	0.290	—	0.320	—	0.345	UI
t <sub>DVE</sub>	Input Data Hold After ECLK		0.739	—	0.699	—	0.703	—	UI
f <sub>DATA</sub>	DDR71 Serial Input Data Speed		—	756	—	630	—	524	Mbps
f <sub>DDR71</sub>	DDR71 ECLK Frequency		—	378	—	315	—	262	MHz
f <sub>CLKIN</sub>	7:1 Input Clock Frequency (SCLK) (minimum limited by PLL)		—	108	—	90	—	75	MHz
Generic DDR Outputs with Clock and Data Aligned at Pin Using PCLK Pin for Clock Input – GDDR1_TX.SCLK.Aligned <sup>9, 12</sup>									
t <sub>DIA</sub>	Output Data Invalid After CLK Output	All MachXO2 devices, all sides.	—	0.520	—	0.550	—	0.580	ns
t <sub>DIB</sub>	Output Data Invalid Before CLK Output		—	0.520	—	0.550	—	0.580	ns
f <sub>DATA</sub>	DDR1 Output Data Speed		—	300	—	250	—	208	Mbps
f <sub>DDR1</sub>	DDR1 SCLK frequency		—	150	—	125	—	104	MHz
Generic DDR Outputs with Clock and Data Centered at Pin Using PCLK Pin for Clock Input – GDDR1_TX.SCLK.Centered <sup>9, 12</sup>									
t <sub>DVB</sub>	Output Data Valid Before CLK Output	All MachXO2 devices, all sides.	1.210	—	1.510	—	1.870	—	ns
t <sub>DVA</sub>	Output Data Valid After CLK Output		1.210	—	1.510	—	1.870	—	ns
f <sub>DATA</sub>	DDR1 Output Data Speed		—	300	—	250	—	208	Mbps
f <sub>DDR1</sub>	DDR1 SCLK Frequency (minimum limited by PLL)		—	150	—	125	—	104	MHz
Generic DDRX2 Outputs with Clock and Data Aligned at Pin Using PCLK Pin for Clock Input – GDDR2_TX.ECLK.Aligned <sup>9, 12</sup>									
t <sub>DIA</sub>	Output Data Invalid After CLK Output	MachXO2-640U, MachXO2-1200/U and larger devices, top side only.	—	0.200	—	0.215	—	0.230	ns
t <sub>DIB</sub>	Output Data Invalid Before CLK Output		—	0.200	—	0.215	—	0.230	ns
f <sub>DATA</sub>	DDR2 Serial Output Data Speed		—	664	—	554	—	462	Mbps
f <sub>DDR2</sub>	DDR2 ECLK frequency		—	332	—	277	—	231	MHz
f <sub>SCLK</sub>	SCLK Frequency		—	166	—	139	—	116	MHz

### sysCLOCK PLL Timing

Over Recommended Operating Conditions

Parameter	Descriptions	Conditions	Min.	Max.	Units
$f_{IN}$	Input Clock Frequency (CLKI, CLKFB)		7	400	MHz
$f_{OUT}$	Output Clock Frequency (CLKOP, CLKOS, CLKOS2)		1.5625	400	MHz
$f_{OUT2}$	Output Frequency (CLKOS3 cascaded from CLKOS2)		0.0122	400	MHz
$f_{VCO}$	PLL VCO Frequency		200	800	MHz
$f_{PFD}$	Phase Detector Input Frequency		7	400	MHz
<b>AC Characteristics</b>					
$t_{DT}$	Output Clock Duty Cycle	Without duty trim selected <sup>3</sup>	45	55	%
$t_{DT\_TRIM}^7$	Edge Duty Trim Accuracy		-75	75	%
$t_{PH}^4$	Output Phase Accuracy		-6	6	%
$t_{OPJIT}^{1,8}$	Output Clock Period Jitter	$f_{OUT} > 100$ MHz	—	150	ps p-p
		$f_{OUT} < 100$ MHz	—	0.007	UIPP
	Output Clock Cycle-to-cycle Jitter	$f_{OUT} > 100$ MHz	—	180	ps p-p
		$f_{OUT} < 100$ MHz	—	0.009	UIPP
	Output Clock Phase Jitter	$f_{PFD} > 100$ MHz	—	160	ps p-p
		$f_{PFD} < 100$ MHz	—	0.011	UIPP
	Output Clock Period Jitter (Fractional-N)	$f_{OUT} > 100$ MHz	—	230	ps p-p
		$f_{OUT} < 100$ MHz	—	0.12	UIPP
	Output Clock Cycle-to-cycle Jitter (Fractional-N)	$f_{OUT} > 100$ MHz	—	230	ps p-p
		$f_{OUT} < 100$ MHz	—	0.12	UIPP
$t_{SPO}$	Static Phase Offset	Divider ratio = integer	-120	120	ps
$t_W$	Output Clock Pulse Width	At 90% or 10% <sup>3</sup>	0.9	—	ns
$t_{LOCK}^{2,5}$	PLL Lock-in Time		—	15	ms
$t_{UNLOCK}$	PLL Unlock Time		—	50	ns
$t_{IPJIT}^6$	Input Clock Period Jitter	$f_{PFD} \geq 20$ MHz	—	1,000	ps p-p
		$f_{PFD} < 20$ MHz	—	0.02	UIPP
$t_{HI}$	Input Clock High Time	90% to 90%	0.5	—	ns
$t_{LO}$	Input Clock Low Time	10% to 10%	0.5	—	ns
$t_{STABLE}^5$	STANDBY High to PLL Stable		—	15	ms
$t_{RST}$	RST/RESETM Pulse Width		1	—	ns
$t_{RSTREC}$	RST Recovery Time		1	—	ns
$t_{RST\_DIV}$	RESETC/D Pulse Width		10	—	ns
$t_{RSTREC\_DIV}$	RESETC/D Recovery Time		1	—	ns
$t_{ROTATE-SETUP}$	PHASESTEP Setup Time		10	—	ns

## Flash Download Time<sup>1, 2</sup>

Symbol	Parameter	Device	Typ.	Units
$t_{\text{REFRESH}}$	POR to Device I/O Active	LCMXO2-256	0.6	ms
		LCMXO2-640	1.0	ms
		LCMXO2-640U	1.9	ms
		LCMXO2-1200	1.9	ms
		LCMXO2-1200U	1.4	ms
		LCMXO2-2000	1.4	ms
		LCMXO2-2000U	2.4	ms
		LCMXO2-4000	2.4	ms
		LCMXO2-7000	3.8	ms

1. Assumes sysMEM EBR initialized to an all zero pattern if they are used.

2. The Flash download time is measured starting from the maximum voltage of POR trip point.

## JTAG Port Timing Specifications

Symbol	Parameter	Min.	Max.	Units
$f_{\text{MAX}}$	TCK clock frequency	—	25	MHz
$t_{\text{BTCPH}}$	TCK [BSCAN] clock pulse width high	20	—	ns
$t_{\text{BTCPL}}$	TCK [BSCAN] clock pulse width low	20	—	ns
$t_{\text{BTS}}$	TCK [BSCAN] setup time	10	—	ns
$t_{\text{BTH}}$	TCK [BSCAN] hold time	8	—	ns
$t_{\text{BTCO}}$	TAP controller falling edge of clock to valid output	—	10	ns
$t_{\text{BTCODIS}}$	TAP controller falling edge of clock to valid disable	—	10	ns
$t_{\text{BTCOEN}}$	TAP controller falling edge of clock to valid enable	—	10	ns
$t_{\text{BTCRS}}$	BSCAN test capture register setup time	8	—	ns
$t_{\text{BTCRH}}$	BSCAN test capture register hold time	20	—	ns
$t_{\text{BUTCO}}$	BSCAN test update register, falling edge of clock to valid output	—	25	ns
$t_{\text{BTUODIS}}$	BSCAN test update register, falling edge of clock to valid disable	—	25	ns
$t_{\text{BTUPOEN}}$	BSCAN test update register, falling edge of clock to valid enable	—	25	ns

## sysCONFIG Port Timing Specifications

Symbol	Parameter		Min.	Max.	Units
All Configuration Modes					
t <sub>PRGM</sub>	PROGRAMN low pulse accept		55	—	ns
t <sub>PRGMJ</sub>	PROGRAMN low pulse rejection		—	25	ns
t <sub>INITL</sub>	INITN low time	LCMXO2-256	—	30	μs
		LCMXO2-640	—	35	μs
		LCMXO2-640U/ LCMXO2-1200	—	55	μs
		LCMXO2-1200U/ LCMXO2-2000	—	70	μs
		LCMXO2-2000U/ LCMXO2-4000	—	105	μs
		LCMXO2-7000	—	130	μs
t <sub>DPPINIT</sub>	PROGRAMN low to INITN low		—	150	ns
t <sub>DPPDONE</sub>	PROGRAMN low to DONE low		—	150	ns
t <sub>IODISS</sub>	PROGRAMN low to I/O disable		—	120	ns
Slave SPI					
f <sub>MAX</sub>	CCLK clock frequency		—	66	MHz
t <sub>CCLKH</sub>	CCLK clock pulse width high		7.5	—	ns
t <sub>CCLKL</sub>	CCLK clock pulse width low		7.5	—	ns
t <sub>STSU</sub>	CCLK setup time		2	—	ns
t <sub>STH</sub>	CCLK hold time		0	—	ns
t <sub>STCO</sub>	CCLK falling edge to valid output		—	10	ns
t <sub>STOZ</sub>	CCLK falling edge to valid disable		—	10	ns
t <sub>STOV</sub>	CCLK falling edge to valid enable		—	10	ns
t <sub>SCS</sub>	Chip select high time		25	—	ns
t <sub>SCSS</sub>	Chip select setup time		3	—	ns
t <sub>SCSH</sub>	Chip select hold time		3	—	ns
Master SPI					
f <sub>MAX</sub>	MCLK clock frequency		—	133	MHz
t <sub>MCLKH</sub>	MCLK clock pulse width high		3.75	—	ns
t <sub>MCLKL</sub>	MCLK clock pulse width low		3.75	—	ns
t <sub>STSU</sub>	MCLK setup time		5	—	ns
t <sub>STH</sub>	MCLK hold time		1	—	ns
t <sub>CSSPI</sub>	INITN high to chip select low		100	200	ns
t <sub>MCLK</sub>	INITN high to first MCLK edge		0.75	1	μs

### Pinout Information Summary

	MachXO2-256					MachXO2-640			MachXO2-640U
	32 QFN <sup>1</sup>	48 QFN <sup>3</sup>	64 ucBGA	100 TQFP	132 csBGA	48 QFN <sup>3</sup>	100 TQFP	132 csBGA	144 TQFP
<b>General Purpose I/O per Bank</b>									
Bank 0	8	10	9	13	13	10	18	19	27
Bank 1	2	10	12	14	14	10	20	20	26
Bank 2	9	10	11	14	14	10	20	20	28
Bank 3	2	10	12	14	14	10	20	20	26
Bank 4	0	0	0	0	0	0	0	0	0
Bank 5	0	0	0	0	0	0	0	0	0
Total General Purpose Single Ended I/O	21	40	44	55	55	40	78	79	107
<b>Differential I/O per Bank</b>									
Bank 0	4	5	5	7	7	5	9	10	14
Bank 1	1	5	6	7	7	5	10	10	13
Bank 2	4	5	5	7	7	5	10	10	14
Bank 3	1	5	6	7	7	5	10	10	13
Bank 4	0	0	0	0	0	0	0	0	0
Bank 5	0	0	0	0	0	0	0	0	0
Total General Purpose Differential I/O	10	20	22	28	28	20	39	40	54
<b>Dual Function I/O</b>									
	22	25	27	29	29	25	29	29	33
<b>High-speed Differential I/O</b>									
Bank 0	0	0	0	0	0	0	0	0	7
<b>Gearboxes</b>									
Number of 7:1 or 8:1 Output Gearbox Available (Bank 0)	0	0	0	0	0	0	0	0	7
Number of 7:1 or 8:1 Input Gearbox Available (Bank 2)	0	0	0	0	0	0	0	0	7
<b>DQS Groups</b>									
Bank 1	0	0	0	0	0	0	0	0	2
<b>VCCIO Pins</b>									
Bank 0	2	2	2	2	2	2	2	2	3
Bank 1	1	1	2	2	2	1	2	2	3
Bank 2	2	2	2	2	2	2	2	2	3
Bank 3	1	1	2	2	2	1	2	2	3
Bank 4	0	0	0	0	0	0	0	0	0
Bank 5	0	0	0	0	0	0	0	0	0
VCC	2	2	2	2	2	2	2	2	4
GND <sup>2</sup>	2	1	8	8	8	1	8	10	12
NC	0	0	1	26	58	0	3	32	8
Reserved for Configuration	1	1	1	1	1	1	1	1	1
Total Count of Bonded Pins	32	49	64	100	132	49	100	132	144

1. Lattice recommends soldering the central thermal pad onto the top PCB ground for improved thermal resistance.
2. For 48 QFN package, exposed die pad is the device ground.
3. 48-pin QFN information is 'Advanced'.

**High-Performance Commercial Grade Devices with Voltage Regulator, Halogen Free (RoHS) Packaging**

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-256HC-4SG32C	256	2.5 V / 3.3 V	–4	Halogen-Free QFN	32	COM
LCMXO2-256HC-5SG32C	256	2.5 V / 3.3 V	–5	Halogen-Free QFN	32	COM
LCMXO2-256HC-6SG32C	256	2.5 V / 3.3 V	–6	Halogen-Free QFN	32	COM
LCMXO2-256HC-4SG48C	256	2.5 V / 3.3 V	–4	Halogen-Free QFN	48	COM
LCMXO2-256HC-5SG48C	256	2.5 V / 3.3 V	–5	Halogen-Free QFN	48	COM
LCMXO2-256HC-6SG48C	256	2.5 V / 3.3 V	–6	Halogen-Free QFN	48	COM
LCMXO2-256HC-4UMG64C	256	2.5 V / 3.3 V	–4	Halogen-Free ucBGA	64	COM
LCMXO2-256HC-5UMG64C	256	2.5 V / 3.3 V	–5	Halogen-Free ucBGA	64	COM
LCMXO2-256HC-6UMG64C	256	2.5 V / 3.3 V	–6	Halogen-Free ucBGA	64	COM
LCMXO2-256HC-4TG100C	256	2.5 V / 3.3 V	–4	Halogen-Free TQFP	100	COM
LCMXO2-256HC-5TG100C	256	2.5 V / 3.3 V	–5	Halogen-Free TQFP	100	COM
LCMXO2-256HC-6TG100C	256	2.5 V / 3.3 V	–6	Halogen-Free TQFP	100	COM
LCMXO2-256HC-4MG132C	256	2.5 V / 3.3 V	–4	Halogen-Free csBGA	132	COM
LCMXO2-256HC-5MG132C	256	2.5 V / 3.3 V	–5	Halogen-Free csBGA	132	COM
LCMXO2-256HC-6MG132C	256	2.5 V / 3.3 V	–6	Halogen-Free csBGA	132	COM

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-640HC-4SG48C	640	2.5 V / 3.3 V	–4	Halogen-Free QFN	48	COM
LCMXO2-640HC-5SG48C	640	2.5 V / 3.3 V	–5	Halogen-Free QFN	48	COM
LCMXO2-640HC-6SG48C	640	2.5 V / 3.3 V	–6	Halogen-Free QFN	48	COM
LCMXO2-640HC-4TG100C	640	2.5 V / 3.3 V	–4	Halogen-Free TQFP	100	COM
LCMXO2-640HC-5TG100C	640	2.5 V / 3.3 V	–5	Halogen-Free TQFP	100	COM
LCMXO2-640HC-6TG100C	640	2.5 V / 3.3 V	–6	Halogen-Free TQFP	100	COM
LCMXO2-640HC-4MG132C	640	2.5 V / 3.3 V	–4	Halogen-Free csBGA	132	COM
LCMXO2-640HC-5MG132C	640	2.5 V / 3.3 V	–5	Halogen-Free csBGA	132	COM
LCMXO2-640HC-6MG132C	640	2.5 V / 3.3 V	–6	Halogen-Free csBGA	132	COM

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-640UHC-4TG144C	640	2.5 V / 3.3 V	–4	Halogen-Free TQFP	144	COM
LCMXO2-640UHC-5TG144C	640	2.5 V / 3.3 V	–5	Halogen-Free TQFP	144	COM
LCMXO2-640UHC-6TG144C	640	2.5 V / 3.3 V	–6	Halogen-Free TQFP	144	COM



Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-2000UHC-4FG484C	2112	2.5 V / 3.3 V	–4	Halogen-Free fpBGA	484	COM
LCMXO2-2000UHC-5FG484C	2112	2.5 V / 3.3 V	–5	Halogen-Free fpBGA	484	COM
LCMXO2-2000UHC-6FG484C	2112	2.5 V / 3.3 V	–6	Halogen-Free fpBGA	484	COM

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-4000HC-4QN84C	4320	2.5 V / 3.3 V	–4	Halogen-Free QFN	84	COM
LCMXO2-4000HC-5QN84C	4320	2.5 V / 3.3 V	–5	Halogen-Free QFN	84	COM
LCMXO2-4000HC-6QN84C	4320	2.5 V / 3.3 V	–6	Halogen-Free QFN	84	COM
LCMXO2-4000HC-4MG132C	4320	2.5 V / 3.3 V	–4	Halogen-Free csBGA	132	COM
LCMXO2-4000HC-5MG132C	4320	2.5 V / 3.3 V	–5	Halogen-Free csBGA	132	COM
LCMXO2-4000HC-6MG132C	4320	2.5 V / 3.3 V	–6	Halogen-Free csBGA	132	COM
LCMXO2-4000HC-4TG144C	4320	2.5 V / 3.3 V	–4	Halogen-Free TQFP	144	COM
LCMXO2-4000HC-5TG144C	4320	2.5 V / 3.3 V	–5	Halogen-Free TQFP	144	COM
LCMXO2-4000HC-6TG144C	4320	2.5 V / 3.3 V	–6	Halogen-Free TQFP	144	COM
LCMXO2-4000HC-4BG256C	4320	2.5 V / 3.3 V	–4	Halogen-Free caBGA	256	COM
LCMXO2-4000HC-5BG256C	4320	2.5 V / 3.3 V	–5	Halogen-Free caBGA	256	COM
LCMXO2-4000HC-6BG256C	4320	2.5 V / 3.3 V	–6	Halogen-Free caBGA	256	COM
LCMXO2-4000HC-4FTG256C	4320	2.5 V / 3.3 V	–4	Halogen-Free ftBGA	256	COM
LCMXO2-4000HC-5FTG256C	4320	2.5 V / 3.3 V	–5	Halogen-Free ftBGA	256	COM
LCMXO2-4000HC-6FTG256C	4320	2.5 V / 3.3 V	–6	Halogen-Free ftBGA	256	COM
LCMXO2-4000HC-4BG332C	4320	2.5 V / 3.3 V	–4	Halogen-Free caBGA	332	COM
LCMXO2-4000HC-5BG332C	4320	2.5 V / 3.3 V	–5	Halogen-Free caBGA	332	COM
LCMXO2-4000HC-6BG332C	4320	2.5 V / 3.3 V	–6	Halogen-Free caBGA	332	COM
LCMXO2-4000HC-4FG484C	4320	2.5 V / 3.3 V	–4	Halogen-Free fpBGA	484	COM
LCMXO2-4000HC-5FG484C	4320	2.5 V / 3.3 V	–5	Halogen-Free fpBGA	484	COM
LCMXO2-4000HC-6FG484C	4320	2.5 V / 3.3 V	–6	Halogen-Free fpBGA	484	COM

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-2000ZE-1UWG49ITR <sup>1</sup>	2112	1.2 V	–1	Halogen-Free WLCSP	49	IND
LCMXO2-2000ZE-1UWG49ITR50 <sup>3</sup>	2112	1.2 V	–1	Halogen-Free WLCSP	49	IND
LCMXO2-2000ZE-1UWG49ITR1K <sup>2</sup>	2112	1.2 V	–1	Halogen-Free WLCSP	49	IND
LCMXO2-2000ZE-1TG100I	2112	1.2 V	–1	Halogen-Free TQFP	100	IND
LCMXO2-2000ZE-2TG100I	2112	1.2 V	–2	Halogen-Free TQFP	100	IND
LCMXO2-2000ZE-3TG100I	2112	1.2 V	–3	Halogen-Free TQFP	100	IND
LCMXO2-2000ZE-1MG132I	2112	1.2 V	–1	Halogen-Free csBGA	132	IND
LCMXO2-2000ZE-2MG132I	2112	1.2 V	–2	Halogen-Free csBGA	132	IND
LCMXO2-2000ZE-3MG132I	2112	1.2 V	–3	Halogen-Free csBGA	132	IND
LCMXO2-2000ZE-1TG144I	2112	1.2 V	–1	Halogen-Free TQFP	144	IND
LCMXO2-2000ZE-2TG144I	2112	1.2 V	–2	Halogen-Free TQFP	144	IND
LCMXO2-2000ZE-3TG144I	2112	1.2 V	–3	Halogen-Free TQFP	144	IND
LCMXO2-2000ZE-1BG256I	2112	1.2 V	–1	Halogen-Free caBGA	256	IND
LCMXO2-2000ZE-2BG256I	2112	1.2 V	–2	Halogen-Free caBGA	256	IND
LCMXO2-2000ZE-3BG256I	2112	1.2 V	–3	Halogen-Free caBGA	256	IND
LCMXO2-2000ZE-1FTG256I	2112	1.2 V	–1	Halogen-Free ftBGA	256	IND
LCMXO2-2000ZE-2FTG256I	2112	1.2 V	–2	Halogen-Free ftBGA	256	IND
LCMXO2-2000ZE-3FTG256I	2112	1.2 V	–3	Halogen-Free ftBGA	256	IND

1. This part number has a tape and reel quantity of 5,000 units with a minimum order quantity of 10,000 units. Order quantities must be in increments of 5,000 units. For example, a 10,000 unit order will be shipped in two reels with one reel containing 5,000 units and the other reel with less than 5,000 units (depending on test yields). Unserviced backlog will be canceled.
2. This part number has a tape and reel quantity of 1,000 units with a minimum order quantity of 1,000. Order quantities must be in increments of 1,000 units. For example, a 5,000 unit order will be shipped as 5 reels of 1000 units each.
3. This part number has a tape and reel quantity of 50 units with a minimum order quantity of 50. Order quantities must be in increments of 50 units. For example, a 1,000 unit order will be shipped as 20 reels of 50 units each.

**High Performance Industrial Grade Devices Without Voltage Regulator, Halogen Free (RoHS) Packaging**

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-2000HE-4TG100I	2112	1.2 V	–4	Halogen-Free TQFP	100	IND
LCMXO2-2000HE-5TG100I	2112	1.2 V	–5	Halogen-Free TQFP	100	IND
LCMXO2-2000HE-6TG100I	2112	1.2 V	–6	Halogen-Free TQFP	100	IND
LCMXO2-2000HE-4MG132I	2112	1.2 V	–4	Halogen-Free csBGA	132	IND
LCMXO2-2000HE-5MG132I	2112	1.2 V	–5	Halogen-Free csBGA	132	IND
LCMXO2-2000HE-6MG132I	2112	1.2 V	–6	Halogen-Free csBGA	132	IND
LCMXO2-2000HE-4TG144I	2112	1.2 V	–4	Halogen-Free TQFP	144	IND
LCMXO2-2000HE-5TG144I	2112	1.2 V	–5	Halogen-Free TQFP	144	IND
LCMXO2-2000HE-6TG144I	2112	1.2 V	–6	Halogen-Free TQFP	144	IND
LCMXO2-2000HE-4BG256I	2112	1.2 V	–4	Halogen-Free caBGA	256	IND
LCMXO2-2000HE-5BG256I	2112	1.2 V	–5	Halogen-Free caBGA	256	IND
LCMXO2-2000HE-6BG256I	2112	1.2 V	–6	Halogen-Free caBGA	256	IND
LCMXO2-2000HE-4FTG256I	2112	1.2 V	–4	Halogen-Free ftBGA	256	IND
LCMXO2-2000HE-5FTG256I	2112	1.2 V	–5	Halogen-Free ftBGA	256	IND
LCMXO2-2000HE-6FTG256I	2112	1.2 V	–6	Halogen-Free ftBGA	256	IND

Part Number	LUTs	Supply Voltage	Grade	Package	Leads	Temp.
LCMXO2-2000UHE-4FG484I	2112	1.2 V	–4	Halogen-Free fpBGA	484	IND
LCMXO2-2000UHE-5FG484I	2112	1.2 V	–5	Halogen-Free fpBGA	484	IND
LCMXO2-2000UHE-6FG484I	2112	1.2 V	–6	Halogen-Free fpBGA	484	IND

# MachXO2 Family Data Sheet

## Revision History

March 2017

Data Sheet DS1035

Date	Version	Section	Change Summary
March 2017	3.3	DC and Switching Characteristics	Updated the <a href="#">Absolute Maximum Ratings</a> section. Added standards.
			Updated the <a href="#">sysIO Recommended Operating Conditions</a> section. Added standards.
			Updated the <a href="#">sysIO Single-Ended DC Electrical Characteristics</a> section. Added standards.
			Updated the <a href="#">MachXO2 External Switching Characteristics – HC/HE Devices</a> section. Under 7:1 LVDS Outputs – GDDR71_TX.ECLK.7:1, the $D_{VB}$ and the $D_{VA}$ parameters were changed to $D_{IB}$ and $D_{IA}$ . The parameter descriptions were also modified.
			Updated the <a href="#">MachXO2 External Switching Characteristics – ZE Devices</a> section. Under 7:1 LVDS Outputs – GDDR71_TX.ECLK.7:1, the $D_{VB}$ and the $D_{VA}$ parameters were changed to $D_{IB}$ and $D_{IA}$ . The parameter descriptions were also modified.
			Updated the <a href="#">sysCONFIG Port Timing Specifications</a> section. Corrected the $t_{INITL}$ units from ns to $\mu$ s.
		Pinout Information	Updated the <a href="#">Signal Descriptions</a> section. Revised the descriptions of the PROGRAMN, INITN, and DONE signals.
			Updated the <a href="#">Pinout Information Summary</a> section. Added footnote to MachXO2-1200 32 QFN.
		Ordering Information	Updated the <a href="#">MachXO2 Part Number Description</a> section. Corrected the MG184, BG256, FTG256 package information. Added “(0.8 mm Pitch)” to BG332.
			Updated the <a href="#">Ultra Low Power Industrial Grade Devices, Halogen Free (RoHS) Packaging</a> section. — Updated LCMXO2-1200ZE-1UWG25ITR50 footnote. — Corrected footnote numbering typo. — Added the LCMXO2-2000ZE-1UWG49ITR50 and LCMXO2-2000ZE-1UWG49ITR1K part numbers. Updated/added footnote/s.

Date	Version	Section	Change Summary
May 2016	3.2	All	Moved designation for 84 QFN package information from 'Advanced' to 'Final'.
		Introduction	Updated the Features section. Revised Table 1-1, MachXO2 Family Selection Guide. — Added 'Advanced' 48 QFN package. — Revised footnote 6. — Added footnote 9.
		DC and Switching Characteristics	Updated the MachXO2 External Switching Characteristics – HC/HE Devices section. Added footnote 12.
			Updated the MachXO2 External Switching Characteristics – ZE Devices section. Added footnote 12.
		Pinout Information	Updated the Signal Descriptions section. Added information on GND signal.
			Updated the Pinout Information Summary section. — Added 'Advanced' MachXO2-256 48 QFN values. — Added 'Advanced' MachXO2-640 48 QFN values. — Added footnote to GND. — Added footnotes 2 and 3.
		Ordering Information	Updated the MachXO2 Part Number Description section. Added 'Advanced' SG48 package and revised footnote.
			Updated the Ordering Information section. — Added part numbers for 'Advanced' QFN 48 package.
March 2016	3.1	Introduction	Updated the Features section. Revised Table 1-1, MachXO2 Family Selection Guide. — Added 32 QFN value for XO2-1200. — Added 84 QFN (7 mm x 7 mm, 0.5 mm) package. — Modified package name to 100-pin TQFP. — Modified package name to 144-pin TQFP. — Added footnote.
		Architecture	Updated the Typical I/O Behavior During Power-up section. Removed reference to TN1202.
		DC and Switching Characteristics	Updated the sysCONFIG Port Timing Specifications section. Revised t <sub>DPPDONE</sub> and t <sub>DPPINIT</sub> Max. values per PCN 03A-16, released March 2016.
		Pinout Information	Updated the Pinout Information Summary section. — Added MachXO2-1200 32 QFN values. — Added 'Advanced' MachXO2-4000 84 QFN values.
		Ordering Information	Updated the MachXO2 Part Number Description section. Added 'Advanced' QN84 package and footnote.
			Updated the Ordering Information section. — Added part numbers for 1280 LUTs QFN 32 package. — Added part numbers for 4320 LUTs QFN 84 package.
March 2015	3.0	Introduction	Updated the Features section. Revised Table 1-1, MachXO2 Family Selection Guide. — Changed 64-ball ucBGA dimension.
		Architecture	Updated the Device Configuration section. Added JTAGENB to TAP dual purpose pins.