The Automotive-Grade Device Handbook

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1. Overview

1.1. Intel Automotive-Grade Devices

Intel automotive-grade devices are certified to AEC-Q100 (Grade 2 level) and are available in CPLD, FPGA, and system on a chip (SoC).You can use these devices in high-temperature environments, such as in automotive sectors.

1.2. Intel® Automotive Qualifications

The automotive grade devices are designed and developed per a quality management system (QMS) that is registered to ISO 9001:2015. The scope of the ISO 9001:2015 registration includes design, development, and provision of semiconductor components, intellectual properties, and software tools. All the foundry, assembly, and test sites that manufacture the automotive devices are operating a QMS that is registered to IATF 16949 in addition to ISO 9001:2015.

Some Intel® devices comply with the following Functional Safety (FuSa) standards:

- ISO 26262
- IEC 61508

For more information about FuSa, contact your Intel sales representative.

Intel provides certified Automotive Functional Safety Data Package (AFSDP) for devices that comply with ISO 26262. AFSDP delivers the framework, methodology, tools, and IP to assist you in building a safe system with cost and time savings. AFSDP typically saves you 12-18 man-months in certifying your safety critical applications at system level.

AFSDP includes:

- Support for some Intel FPGAs (automotive-grade Cyclone® V, Cyclone V SoC, and Intel MAX® 10)
- Support for the Intel Quartus® Prime software version 14.1 and the Intel Quartus Prime Standard Edition software version 17.0.2
- FMEDA tool
- Diagnostic and standard intellectual property (IP)
- Safety manual
- Certificate

Related Information

- Accelerate Automotive with Intel FPGAS, Intel page
  Provides more information about Intel automotive solutions.

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ISO 9001:2015 Registered

- AN 704: FPGA-based Safety Separation Design Flow for Rapid Functional Safety Certification
- A Safety Methodology for ADAS Designs in FPGAs white paper
  Provides more information on Advanced Driver Assisted Systems (ADAS) applications.
- Next-Generation Transportation, Intel page
- Automotive Applications, Intel page
  Provides more information on functional safety for automotive applications.
- Industrial Automation, Intel page
  Provides more information on functional safety for industrial automation.
- Intel Programmable Solutions Group ISO 9001:2015 Certification

1.3. Supported Device Families

Table 1. Intel Automotive-Grade Device Families

Category	Product Family	Quartus Software Support (1)	Description
IC, FPGA	Intel Cyclone 10 LP	Version 17.1 and later	Low-cost, low-power, feature-rich FPGAs
IC, FPGA	Intel MAX 10	Version 15.1.2 and later	Low-cost, instant-on, small form factor programmable logic device, integrated analog module
IC, SoC	Cyclone V SoC	Version 12.1 and later	Low-cost, low-power, user-customizable ARM-based SoC devices
IC, FPGA	Cyclone V	Version 11.1 and later	Low-cost, low-power, feature-rich 28 nm FPGAs
IC, FPGA	Cyclone IV	Version 9.1 SP2 and later	Low-cost, low-power, feature-rich 60 nm FPGAs (1.2 V)
IC, CPLD	MAX V	Version 11.0 and later	High-density, low-power glue logic CPLDs (1.8 V)
IC, CPLD	MAX II	Version 7.2 SP1 and later	High-density, low-power glue logic CPLDs (3.3 V, 2.5 V)

Volume Production Support for Legacy Device Families			
Category	**Product Family**	**Quartus Software Support (2)**	**Description**
IC, FPGA	Cyclone III	Version 8.0 to 13.1	Low-cost, feature-rich 65 nm FPGAs
IC, FPGA	Cyclone II	Version 7.2 SP1 to 13.0	Low-cost, feature-rich 90 nm FPGAs
IC, FPGA	Cyclone	Version 7.2 SP1 to 13.0	Low-cost, glue logic 130 nm FPGAs
IC, CPLD	MAX 7000AE	Version 7.2 SP1 to 13.0	High-performance, glue logic CPLDs (5-V I/O compatible)

(1) Starting from version 15.1, the Quartus II software is known as the Intel Quartus Prime Standard Edition software.

(2) The legacy devices are only supported in the Quartus II software.

2. Supported Automotive-Grade Devices

2.1. Intel Cyclone 10 LP Devices

2.1.1. Supported Automotive-Grade Devices

Table 2. Automotive-Grade in Intel Cyclone 10 LP Devices

Other automotive-grade product line/package combinations or ordering codes might be available upon request. Consult your Intel sales representative to submit your request.

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
10CL006YE144A7G	10CL006	144-pin EQFP	–40°C to 125°C	–7
10CL006YU256A7G	10CL006	256-pin UBGA	–40°C to 125°C	–7
10CL010YE144A7G	10CL010	144-pin EQFP	–40°C to 125°C	–7
10CL010YM164A7G	10CL010	164-pin MBGA	–40°C to 125°C	–7
10CL010YU256A7G	10CL010	256-pin UBGA	–40°C to 125°C	–7
10CL016YE144A7G	10CL016	144-pin EQFP	–40°C to 125°C	–7
10CL016YM164A7G	10CL016	164-pin MBGA	–40°C to 125°C	–7
10CL016YU256A7G	10CL016	256-pin UBGA	–40°C to 125°C	–7
10CL025YE144A7G	10CL025	144-pin EQFP	–40°C to 125°C	–7
10CL025YU256A7G	10CL025	256-pin UBGA	–40°C to 125°C	–7
10CL025YU484A7G	10CL025	484-pin UBGA	–40°C to 125°C	–7
10CL040YU484A7G	10CL040	484-pin UBGA	–40°C to 125°C	–7
10CL055YU484A7G	10CL055	484-pin UBGA	–40°C to 125°C	–7
10CL080YU484A7G	10CL080	484-pin UBGA	–40°C to 125°C	–7

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*Other names and brands may be claimed as the property of others.

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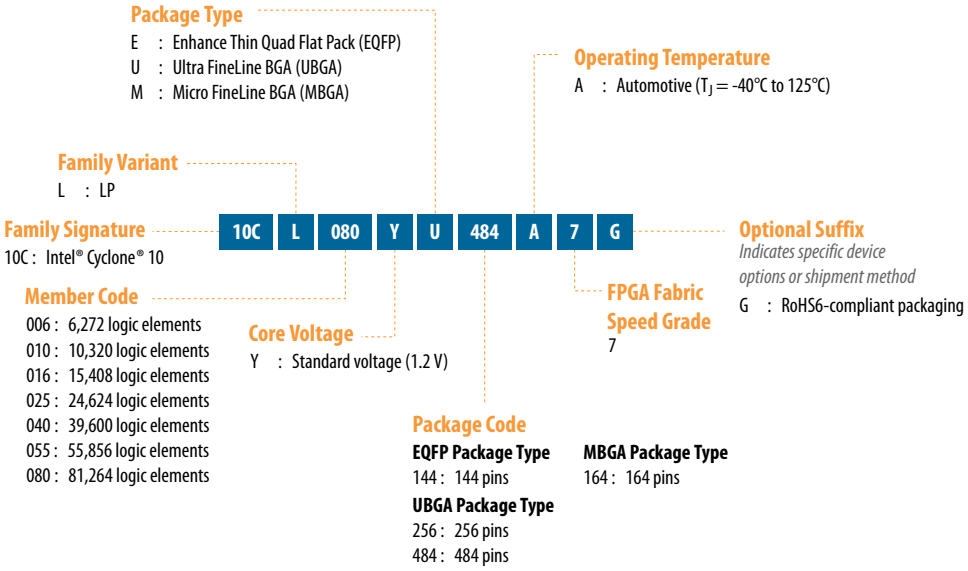
2.1.2. Package Options and Maximum User I/Os

Table 3. Package Options and Maximum User I/Os in Intel Cyclone 10 LP Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line						
			10CL006	10CL010	10CL016	10CL025	10CL040	10CL055	10CL080
			(6K LEs)	(10K LEs)	(16K LEs)	(25K LEs)	(40K LEs)	(55K LEs)	(80K LEs)
			GPIO / LVDS						
MBGA-164	0.5	8 × 8	—	71 / 22	71 / 22	—	—	—	—
UBGA-256	0.8	14 × 14	176 / 65	176 / 65	162 / 53	150 / 52	—	—	—
UBGA-484	0.8	19 × 19	—	—	—	325 / 124	325 / 124	321 / 132	289 / 110
EQFP-144	0.5	22 × 22	88 / 22	88 / 22	78 / 19	76 / 18	—	—	—

2.1.3. Device Ordering Codes

Figure 1. Automotive-Grade Ordering Information for Intel Cyclone 10 LP Devices



2.2. Intel MAX 10 Devices

2.2.1. Supported Automotive-Grade Devices

Table 4. Automotive-Grade in Intel MAX 10 Devices

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
10M02SCE144A7G	10M02SC	144-pin EQFP	–40°C to 125°C	–7
10M02SCU169A7G	10M02SC	169-pin UBGA	–40°C to 125°C	–7
10M02DCU324A7G	10M02DC	324-pin UBGA	–40°C to 125°C	–7

continued...

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
10M04SAE144A7G	10M04SA	144-pin EQFP	–40°C to 125°C	–7
10M04SAU169A7G	10M04SA	169-pin UBGA	–40°C to 125°C	–7
10M04SCE144A7G	10M04SC	144-pin EQFP	–40°C to 125°C	–7
10M04SCU169A7G	10M04SC	169-pin UBGA	–40°C to 125°C	–7
10M04DAF256A7G	10M04DA	256-pin FBGA	–40°C to 125°C	–7
10M04DCF256A7G	10M04DC	256-pin FBGA	–40°C to 125°C	–7
10M04DCU324A7G	10M04DC	324-pin UBGA	–40°C to 125°C	–7
10M08SAE144A7G	10M08SA	144-pin EQFP	–40°C to 125°C	–7
10M08SAU169A7G	10M08SA	169-pin UBGA	–40°C to 125°C	–7
10M08SCE144A7G	10M08SC	144-pin EQFP	–40°C to 125°C	–7
10M08SCU169A7G	10M08SC	169-pin UBGA	–40°C to 125°C	–7
10M08DAF256A7G	10M08DA	256-pin FBGA	–40°C to 125°C	–7
10M08DCF256A7G	10M08DC	256-pin FBGA	–40°C to 125°C	–7
10M08DCU324A7G	10M08DC	324-pin UBGA	–40°C to 125°C	–7
10M16SAE144A7G	10M16SA	144-pin EQFP	–40°C to 125°C	–7
10M16SAU169A7G	10M16SA	169-pin UBGA	–40°C to 125°C	–7
10M16SCE144A7G	10M16SC	144-pin EQFP	–40°C to 125°C	–7
10M16SCU169A7G	10M16SC	169-pin UBGA	–40°C to 125°C	–7
10M16DAF256A7G	10M16DA	256-pin FBGA	–40°C to 125°C	–7
10M16DAF484A7G	10M16DA	484-pin FBGA	–40°C to 125°C	–7
10M16DCF256A7G	10M16DC	256-pin FBGA	–40°C to 125°C	–7
10M16DCU324A7G	10M16DC	324-pin UBGA	–40°C to 125°C	–7
10M16DCF484A7G	10M16DC	484-pin FBGA	–40°C to 125°C	–7
10M25SAE144A7G	10M25SA	144-pin EQFP	–40°C to 125°C	–7
10M25SCE144A7G	10M25SC	144-pin EQFP	–40°C to 125°C	–7
10M25DAF256A7G	10M25DA	256-pin FBGA	–40°C to 125°C	–7
10M25DAF484A7G	10M25DA	484-pin FBGA	–40°C to 125°C	–7
10M25DCF256A7G	10M25DC	256-pin FBGA	–40°C to 125°C	–7
10M25DCF484A7G	10M25DC	484-pin FBGA	–40°C to 125°C	–7
10M40SCE144A7G	10M40SC	144-pin EQFP	–40°C to 125°C	–7
10M40DCF256A7G	10M40DC	256-pin FBGA	–40°C to 125°C	–7
10M50SCE144A7G	10M50SC	144-pin EQFP	–40°C to 125°C	–7
10M50DCF256A7G	10M50DC	256-pin FBGA	–40°C to 125°C	–7

2.2.2. Package Options and Maximum User I/Os

Table 5. Package Options and Maximum User I/Os in Intel MAX 10 Single Power Supply Devices

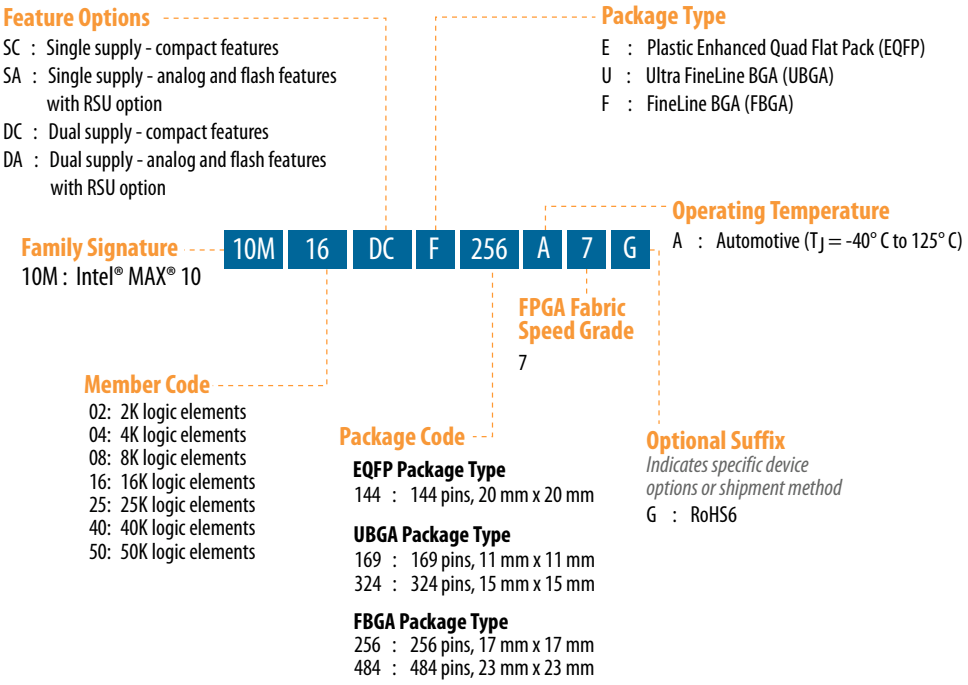
Device	Package		
	Type	U169 169-pin UBGA	E144 144-pin EQFP
	Size	11 mm × 11 mm	22 mm × 22 mm
	Pitch	0.8 mm	0.5 mm
10M02S		130	101
10M04S		130	101
10M08S		130	101
10M16S		130	101
10M25S		—	101
10M40S		—	101
10M50S		—	101

Table 6. Package Options and Maximum User I/Os in Intel MAX 10 Dual Power Supply Devices

Device	Package			
	Type	U324 324-pin UBGA	F256 256-pin FBGA	F484 484-pin FBGA
	Size	15 mm × 15 mm	17 mm × 17 mm	23 mm × 23 mm
	Ball Pitch	0.8 mm	1.0 mm	1.0 mm
10M02D		160	—	—
10M04D		246	178	—
10M08D		246	178	250
10M16D		246	178	320
10M25D		—	178	360
10M40D		—	178	360
10M50D		—	178	360

2.2.3. Device Ordering Codes

Figure 2. Automotive-Grade Ordering Information for Intel MAX 10 Devices



2.3. Cyclone V SoC Devices

2.3.1. Supported Automotive-Grade Devices

Table 7. Automotive-Grade in Cyclone V SoC Devices

Other automotive-grade product line/package combinations or ordering codes might be available upon request. Consult your Intel sales representative to submit your request.

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
5CSEBA2U19A7N	5CSEBA2	484-pin UBGA	–40°C to 125°C	–7
5CSEBA2U23A7N	5CSEBA2	672-pin UBGA	–40°C to 125°C	–7
5CSEMA2U23A7N	5CSEMA2	672-pin UBGA	–40°C to 125°C	–7
5CSEBA4U19A7N	5CSEBA4	484-pin UBGA	–40°C to 125°C	–7
5CSEBA4U23A7N	5CSEBA4	672-pin UBGA	–40°C to 125°C	–7
5CSEMA4U23A7N	5CSEMA4	672-pin UBGA	–40°C to 125°C	–7
5CSEBA5U19A7N	5CSEBA5	484-pin UBGA	–40°C to 125°C	–7
5CSEBA5U23A7N	5CSEBA5	672-pin UBGA	–40°C to 125°C	–7
5CSEMA5U23A7N	5CSEMA5	672-pin UBGA	–40°C to 125°C	–7
5CSEMA5F31A7N	5CSEMA5	896-pin FBGA	–40°C to 125°C	–7

continued...

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
5CSEBA6U19A7N	5CSEBA6	484-pin UBGA	–40°C to 125°C	–7
5CSEBA6U23A7N	5CSEBA6	672-pin UBGA	–40°C to 125°C	–7
5CSEMA6U23A7N	5CSEMA6	672-pin UBGA	–40°C to 125°C	–7
5CSEMA6F31A7N	5CSEMA6	896-pin FBGA	–40°C to 125°C	–7
5CSXFC2C6U23A7N	5CSXFC2	672-pin UBGA	–40°C to 125°C	–7
5CSXFC4C6U23A7N	5CSXFC4	672-pin UBGA	–40°C to 125°C	–7
5CSXFC5C6U23A7N	5CSXFC5	672-pin UBGA	–40°C to 125°C	–7
5CSXFC6C6U23A7N	5CSXFC6	672-pin UBGA	–40°C to 125°C	–7
5CSXFC6D6F31A7N	5CSXFC6	896-pin FBGA	–40°C to 125°C	–7

2.3.2. Package Options and Maximum User I/Os

Table 8. Package Options and Maximum User I/Os in Cyclone V SE Devices

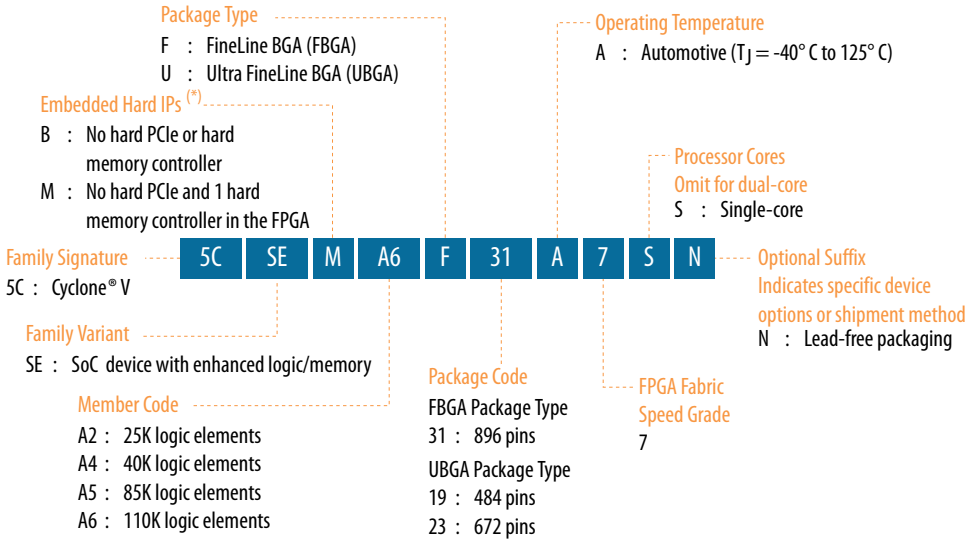
Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line			
			5CSEA2	5CSEA4	5CSEA5	5CSEA6
			(25K LEs)	(40K LEs)	(85K LEs)	(110K LEs)
			FPGA I/Os / HPS I/Os			
UBGA-484	0.8	19 x 19	66 / 151	66 / 151	66 / 151	66 / 151
UBGA-672	0.8	23 x 23	145 / 181	145 / 181	145 / 181	145 / 181
FBGA-896	1	31 x 31	—	—	288 / 181	288 / 181

Table 9. Package Options and Maximum User I/Os in Cyclone V SX Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line			
			5CSXC2	5CSXC4	5CSXC5	5CSXC6
			(25K LEs)	(40K LEs)	(85K LEs)	(110K LEs)
			FPGA I/Os / HPS I/Os / XCVRs			
UBGA-672	0.8	23 x 23	145 / 181 / 6	145 / 181 / 6	145 / 181 / 6	145 / 181 / 6
FBGA-896	1	31 x 31	—	—	—	288 / 181 / 9

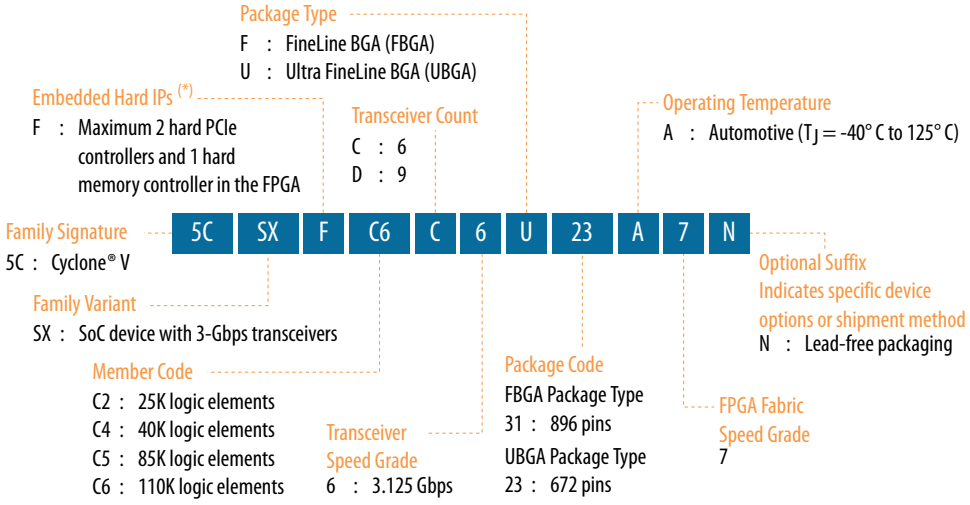
2.3.3. Device Ordering Codes

Figure 3. Automotive-Grade Ordering Information for Cyclone V SE Devices



Note:
* All Cyclone V SoC devices include one hard memory controller dedicated to the processor and which can be shared by the FPGA.

Figure 4. Automotive-Grade Ordering Information for Cyclone V SX Devices



Note:
* All Cyclone V SoC devices include one hard memory controller dedicated to the processor and which can be shared by the FPGA.

2.4. Cyclone V Devices

2.4.1. Supported Automotive-Grade Devices

Table 10. Automotive-Grade in Cyclone V Devices

Other automotive-grade product line/package combinations or ordering codes might be available upon request. Consult your Intel sales representative to submit your request.

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
5CEBA2F17A7N	5CEBA2	256-pin FBGA	–40°C to 125°C	–7
5CEFA2U19A7N	5CEFA2	484-pin UBGA	–40°C to 125°C	–7
5CEBA4F17A7N	5CEBA4	256-pin FBGA	–40°C to 125°C	–7
5CEFA4U19A7N	5CEFA4	484-pin UBGA	–40°C to 125°C	–7
5CEFA5U19A7N	5CEFA5	484-pin UBGA	–40°C to 125°C	–7
5CEFA7U19A7N	5CEFA7	484-pin UBGA	–40°C to 125°C	–7
5CEFA9U19A7N	5CEFA9	484-pin UBGA	–40°C to 125°C	–7
5CGXFC3B6U15A7N	5CGXFC3	324-pin UBGA	–40°C to 125°C	–7
5CGXFC3B6U19A7N	5CGXFC3	484-pin UBGA	–40°C to 125°C	–7
5CGXFC4C6U19A7N	5CGXFC4	484-pin UBGA	–40°C to 125°C	–7
5CGXFC5C6U19A7N	5CGXFC5	484-pin UBGA	–40°C to 125°C	–7
5CGXFC5C6F23A7N	5CGXFC5	484-pin FBGA	–40°C to 125°C	–7
5CGXFC7C6U19A7N	5CGXFC7	484-pin UBGA	–40°C to 125°C	–7
5CGXFC7D6F31A7N	5CGXFC7	896-pin FBGA	–40°C to 125°C	–7
5CGXFC9A6U19A7N	5CGXFC9	484-pin UBGA	–40°C to 125°C	–7

2.4.2. Package Options and Maximum User I/Os

Table 11. Package Options and Maximum User I/Os in Cyclone V E Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line				
			5CEA2	5CEA4	5CEA5	5CEA7	5CEA9
			(25K LEs)	(49K LEs)	(77K LEs)	(149.5K LEs)	(301K LEs)
			I/Os				
FBGA-256	1	17 x 17	128	128	—	—	—
UBGA-484	0.8	19 x 19	224	224	224	240	240

Table 12. Package Options and Maximum User I/Os in Cyclone V GX Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line				
			5CGXC3 (36K LEs)	5CGXC4 (50K LEs)	5CGXC5 (77K LEs)	5CGXC7 (149.5K LEs)	5CGXC9 (301K LEs)
			I/Os / XCVRs				
UBGA-324	0.8	15 x 15	144 / 3	—	—	—	—
UBGA-484	0.8	19 x 19	208 / 3	224 / 6	224 / 6	240 / 6	240 / 5
FBGA-484	1	23 x 23	—	—	240 / 6	—	—
FBGA-896	1	31 x 31	—	—	—	480 / 9	—

2.4.3. Device Ordering Codes

Figure 5. Automotive-Grade Ordering Information for Cyclone V E Devices

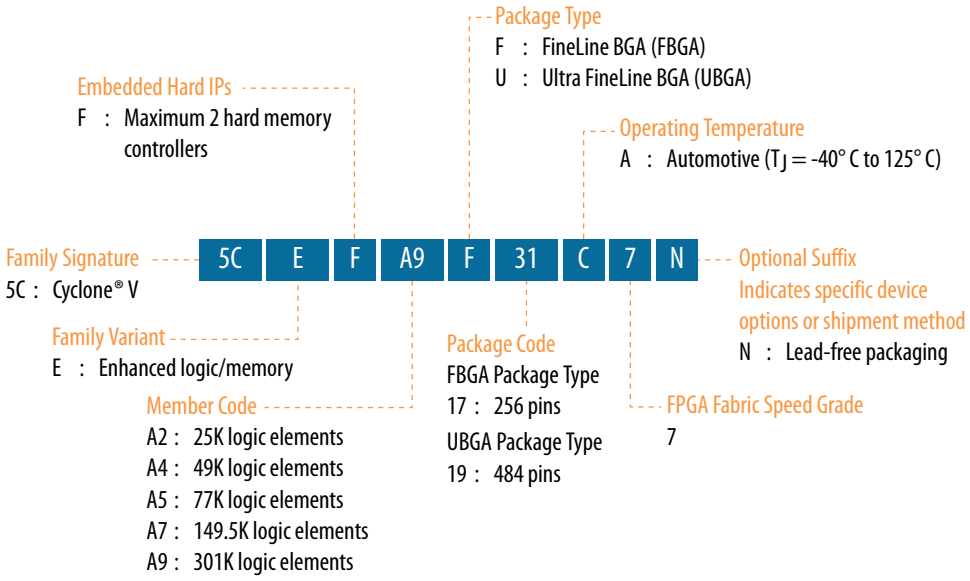
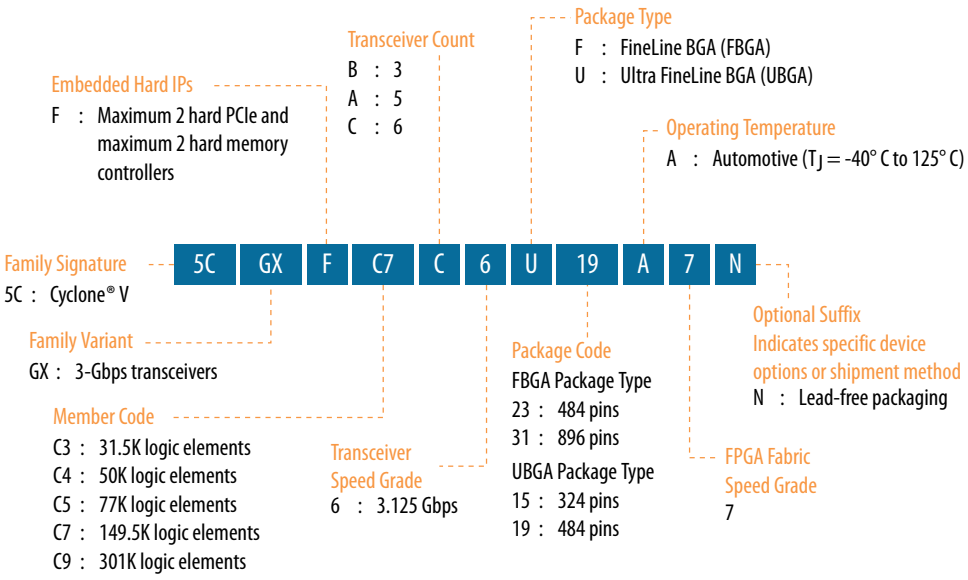


Figure 6. Automotive-Grade Ordering Information for Cyclone V GX Devices



2.5. Cyclone IV Devices

2.5.1. Supported Automotive-Grade Devices

Table 13. Automotive-Grade in Cyclone IV Devices

Other automotive-grade product line/package combinations or ordering codes might be available upon request. Consult your Intel sales representative to submit your request.

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EP4CE6F17A7N	EP4CE6	256-pin FBGA	–40°C to 125°C	–7
EP4CE6E22A7N	EP4CE6	144-pin EQFP	–40°C to 125°C	–7
EP4CE10F17A7N	EP4CE10	256-pin FBGA	–40°C to 125°C	–7
EP4CE10E22A7N	EP4CE10	144-pin EQFP	–40°C to 125°C	–7
EP4CE15F17A7N	EP4CE15	256-pin FBGA	–40°C to 125°C	–7
EP4CE15F23A7N	EP4CE15	484-pin FBGA	–40°C to 125°C	–7
EP4CE15U14A7N	EP4CE15	256-pin UBGA	–40°C to 125°C	–7
EP4CE22F17A7N	EP4CE22	256-pin FBGA	–40°C to 125°C	–7
EP4CE22E22A7N	EP4CE22	144-pin EQFP	–40°C to 125°C	–7
EP4CE22U14A7N	EP4CE22	256-pin UBGA	–40°C to 125°C	–7
EP4CE30F19A7N	EP4CE30	324-pin FBGA	–40°C to 125°C	–7
EP4CE30F23A7N	EP4CE30	484-pin FBGA	–40°C to 125°C	–7
EP4CE40F19A7N	EP4CE40	324-pin FBGA	–40°C to 125°C	–7
EP4CE40F23A7N	EP4CE40	484-pin FBGA	–40°C to 125°C	–7

continued...

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EP4CE40U19A7N	EP4CE40	484-pin UBGA	–40°C to 125°C	–7
EP4CE55F23A7N	EP4CE55	484-pin FBGA	–40°C to 125°C	–7
EP4CGX15BF14A7N	EP4CGX15	169-pin FBGA	–40°C to 125°C	–7

2.5.2. Package Options and Maximum User I/Os

Table 14. Package Options and Maximum User I/Os in Cyclone IV E Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line						
			EP4CE6 (6.3K LEs)	EP4CE10 (10.3K LEs)	EP4CE15 (15.4K LEs)	EP4CE22 (22.3K LEs)	EP4CE30 (28.8K LEs)	EP4CE40 (39.6K LEs)	EP4CE55 (55.9K LEs)
			I/Os						
EQFP-144	0.5	22 x 22	91	91	—	79	—	—	—
UBGA-256	0.8	14 x 14	—	—	165	153	—	—	—
FBGA-256	1	17 x 17	179	179	165	153	—	—	—
UBGA-484	0.8	19 x 19	—	—	—	—	—	328	—
FBGA-324	1	19 x 19	—	—	—	—	193	193	—
FBGA-484	1	23 x 23	—	—	343	—	328	328	324

Table 15. Package Options and Maximum User I/Os in Cyclone IV GX Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line
			EP4CGX15 (14.4K LEs)
			I/Os
FBGA-169	1	14 x 14	72 / 2

2.5.3. Device Ordering Codes

Figure 7. Automotive-Grade Ordering Information for Cyclone IV E Devices

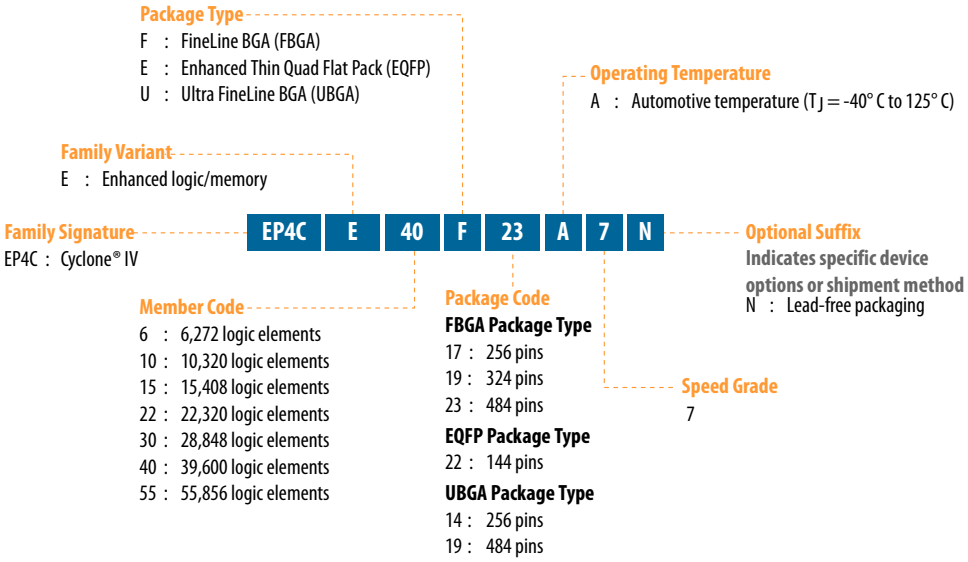
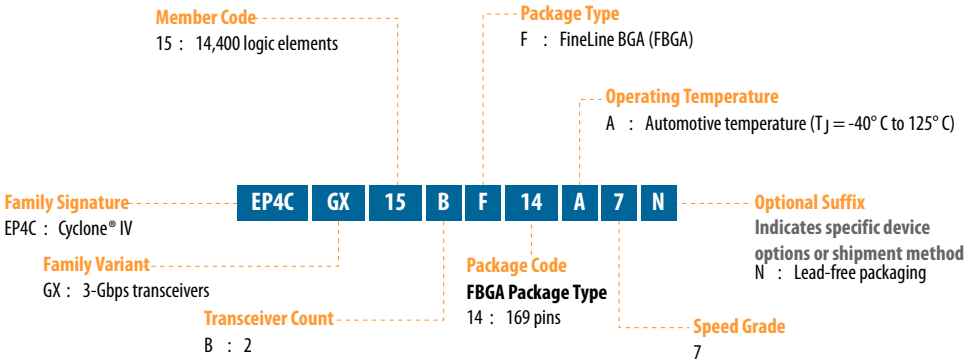


Figure 8. Automotive-Grade Ordering Information for Cyclone IV GX Devices



2.6. MAX V Devices

2.6.1. Supported Automotive-Grade Devices

Table 16. Automotive-Grade in MAX V Devices

Other automotive-grade product line/package combinations or ordering codes might be available upon request. Consult your Intel sales representative to submit your request.

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
5M40ZE64A5N	5M40Z	64-pin EQFP	–40°C to 125°C	–5
5M80ZE64A5N	5M80Z	64-pin EQFP	–40°C to 125°C	–5
5M80ZT100A5N	5M80Z	100-pin TQFP	–40°C to 125°C	–5

continued...

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
5M160ZE64A5N	5M160Z	64-pin EQFP	–40°C to 125°C	–5
5M160ZT100A5N	5M160Z	100-pin TQFP	–40°C to 125°C	–5
5M240ZT100A5N	5M240Z	100-pin TQFP	–40°C to 125°C	–5
5M570ZT100A5N	5M570Z	100-pin TQFP	–40°C to 125°C	–5
5M1270ZF256A5N	5M1270Z	256-pin FBGA	–40°C to 125°C	–5
5M1270ZT144A5N	5M1270Z	144-pin TQFP	–40°C to 125°C	–5

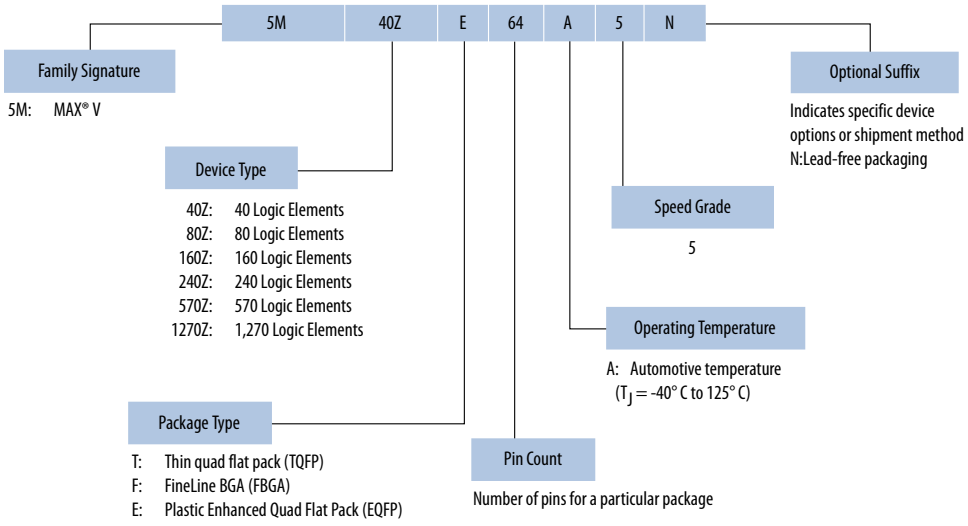
2.6.2. Package Options and Maximum User I/Os

Table 17. Package Options and Maximum User I/Os in MAX V Devices

Package Type/ Pin Count	Ball Spacing (mm)	Dimensions (mm)	Product Line					
			5M40Z (40 LEs)	5M80Z (80 LEs)	5M160Z (160 LEs)	5M240Z (240 LEs)	5M570Z (570 LEs)	5M1270Z (1270 LEs)
			I/Os					
EQFP-64	0.5	7 x 7	54	54	54	—	—	—
TQFP-100	0.5	14 x 14	—	79	79	79	74	—
TQFP-144	0.5	20 x 20	—	—	—	—	—	114
FBGA-256	1	17 x 17	—	—	—	—	—	211

2.6.3. Device Ordering Codes

Figure 9. Automotive-Grade Ordering Information for MAX V Devices



2.7. MAX II Devices

2.7.1. Supported Automotive-Grade Devices

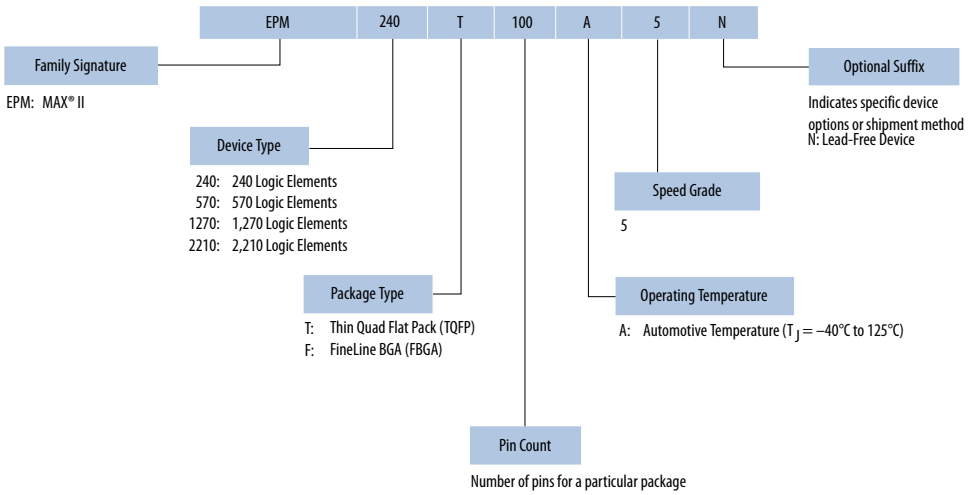
Table 18. Automotive-Grade in MAX II Devices

Other automotive-grade product line/package combinations or ordering codes might be available upon request. Consult your Intel sales representative to submit your request.

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EPM240T100A5N	EPM240	100-pin TQFP	–40°C to 125°C	–5
EPM570F100A5N	EPM570	100-pin FBGA	–40°C to 125°C	–5
EPM570T100A5N	EPM570	100-pin TQFP	–40°C to 125°C	–5
EPM570T144A5N	EPM570	144-pin TQFP	–40°C to 125°C	–5
EPM1270T144A5N	EPM1270	144-pin TQFP	–40°C to 125°C	–5
EPM1270F256A5N	EPM1270	256-pin FBGA	–40°C to 125°C	–5
EPM2210F256A5N	EPM2210	256-pin FBGA	–40°C to 125°C	–5
EPM2210F324A5N	EPM2210	324-pin FBGA	–40°C to 125°C	–5

2.7.2. Device Ordering Codes

Figure 10. Automotive-Grade Ordering Information for MAX II Devices



2.8. Cyclone III Devices (Legacy Support)

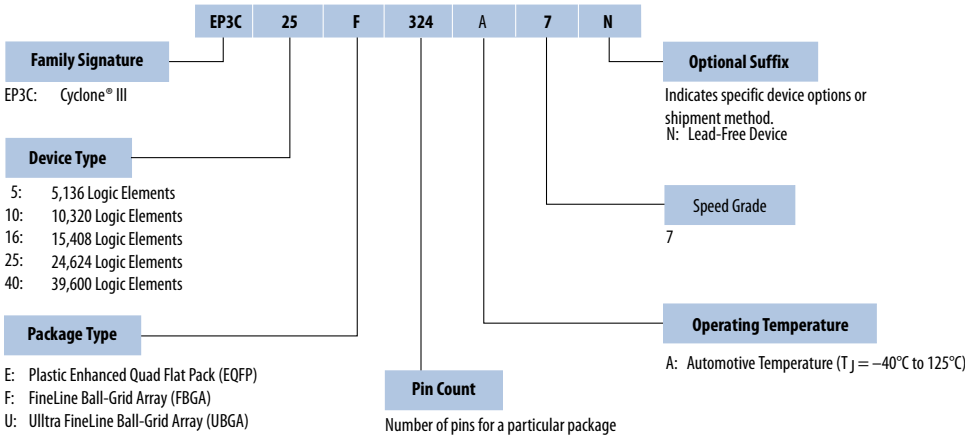
2.8.1. Supported Automotive-Grade Devices

Table 19. Automotive-Grade in Cyclone III Devices

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EP3C5E144A7N	EP3C5	144-pin EQFP	–40°C to 125°C	–7
EP3C5F256A7N	EP3C5	256-pin FBGA	–40°C to 125°C	–7
EP3C5U256A7N	EP3C5	256-pin UBGA	–40°C to 125°C	–7
EP3C10E144A7N	EP3C10	144-pin EQFP	–40°C to 125°C	–7
EP3C10F256A7N	EP3C10	256-pin FBGA	–40°C to 125°C	–7
EP3C10U256A7N	EP3C10	256-pin UBGA	–40°C to 125°C	–7
EP3C16E144A7N	EP3C16	144-pin EQFP	–40°C to 125°C	–7
EP3C16F256A7N	EP3C16	256-pin FBGA	–40°C to 125°C	–7
EP3C16U256A7N	EP3C16	256-pin UBGA	–40°C to 125°C	–7
EP3C16F484A7N	EP3C16	484-pin FBGA	–40°C to 125°C	–7
EP3C16U484A7N	EP3C16	484-pin UBGA	–40°C to 125°C	–7
EP3C25E144A7N	EP3C25	144-pin EQFP	–40°C to 125°C	–7
EP3C25F256A7N	EP3C25	256-pin FBGA	–40°C to 125°C	–7
EP3C25U256A7N	EP3C25	256-pin UBGA	–40°C to 125°C	–7
EP3C25F324A7N	EP3C25	324-pin FBGA	–40°C to 125°C	–7
EP3C40F324A7N	EP3C40	324-pin FBGA	–40°C to 125°C	–7
EP3C40F484A7N	EP3C40	484-pin FBGA	–40°C to 125°C	–7
EP3C40U484A7N	EP3C40	484-pin UBGA	–40°C to 125°C	–7

2.8.2. Device Ordering Codes

Figure 11. Automotive-Grade Ordering Information for Cyclone III Devices



2.9. Cyclone II Devices (Legacy Support)

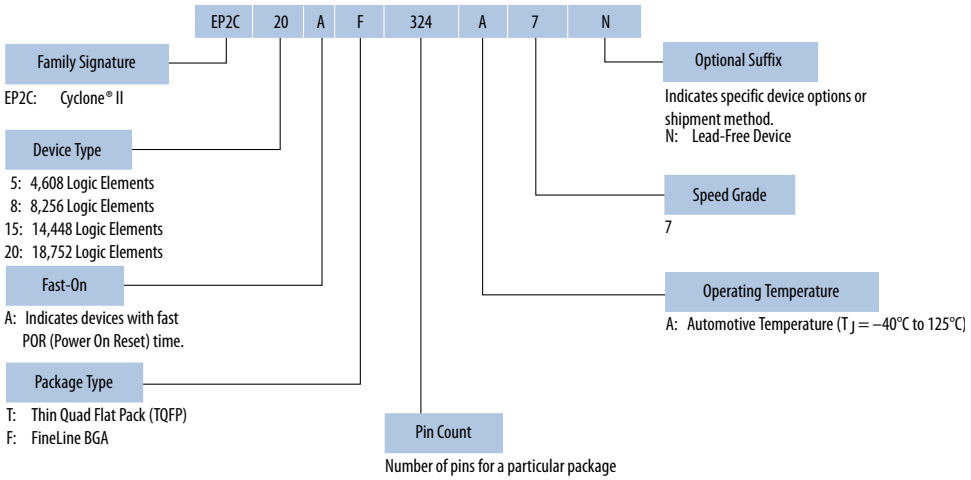
2.9.1. Supported Automotive-Grade Devices

Table 20. Automotive-Grade in Cyclone II Devices

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EP2C5AT144A7N	EP2C5	144-pin TQFP	–40°C to 125°C	–7
EP2C5AF256A7N	EP2C5	256-pin FBGA	–40°C to 125°C	–7
EP2C8AF256A7N	EP2C8	256-pin FBGA	–40°C to 125°C	–7
EP2C15AF256A7N	EP2C15	256-pin FBGA	–40°C to 125°C	–7
EP2C15AF484A7N	EP2C15	484-pin FBGA	–40°C to 125°C	–7
EP2C20AF256A7N	EP2C20	256-pin FBGA	–40°C to 125°C	–7
EP2C20AF484A7N	EP2C20	484-pin FBGA	–40°C to 125°C	–7

2.9.2. Device Ordering Codes

Figure 12. Automotive-Grade Ordering Information for Cyclone II Devices



2.10. Cyclone Devices (Legacy Support)

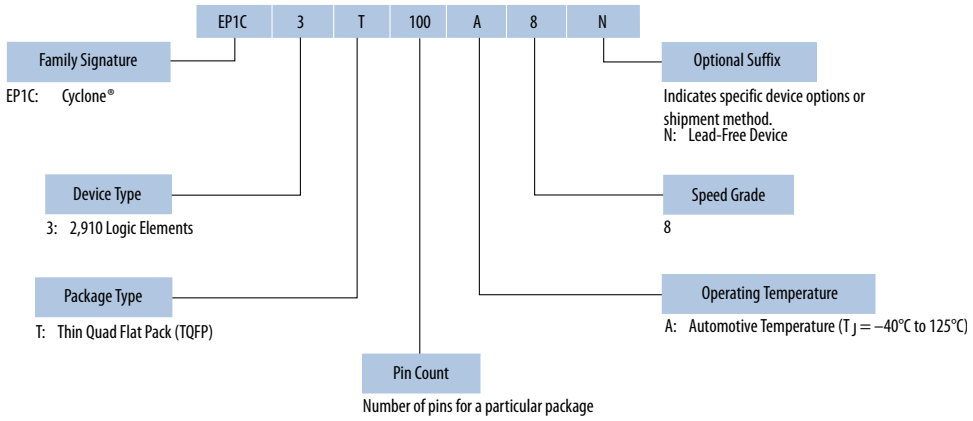
2.10.1. Supported Automotive-Grade Devices

Table 21. Automotive-Grade in Cyclone Devices

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EP1C3T100A8N	EP1C3	100-pin TQFP	–40°C to 125°C	–8
EP1C3T144A8N	EP1C3	144-pin TQFP	–40°C to 125°C	–8

2.10.2. Device Ordering Codes

Figure 13. Automotive-Grade Ordering Information for Cyclone Devices



2.11. MAX 7000A Devices (Legacy Support)

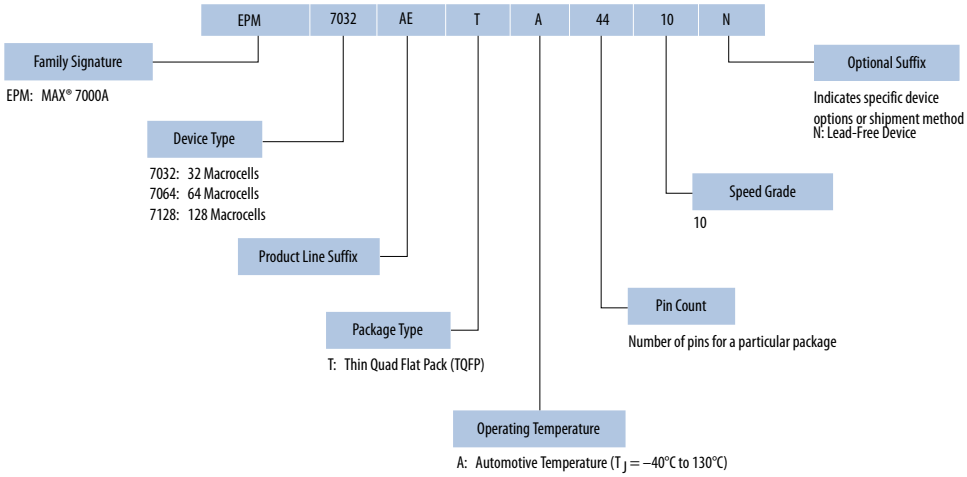
2.11.1. Supported Automotive-Grade Devices

Table 22. Automotive-Grade in MAX 7000A Devices

Device Ordering Code	Device	Package	Junction Temperature Range	Speed Grade
EPM7032AETA44-10N	EPM7032AE	44-pin TQFP	–40°C to 130°C	–10
EPM7064AETA44-10N	EPM7064AE	44-pin TQFP	–40°C to 130°C	–10
EPM7064AETA100-10N	EPM7064AE	100-pin TQFP	–40°C to 130°C	–10
EPM7128AETA100-10N	EPM7128AE	100-pin TQFP	–40°C to 130°C	–10
EPM7128AETA144-10N	EPM7128AE	144-pin TQFP	–40°C to 130°C	–10

2.11.2. Device Ordering Codes

Figure 14. Automotive-Grade Ordering Information for MAX 7000A Devices



3. Intel Quartus Prime Software Support

The Intel Quartus Prime design software supports the automotive-grade devices in the automotive temperature range. The Intel Quartus Prime software provides a comprehensive environment for SoC design. It also includes HDL and schematic design entry, compilation and logic synthesis, full simulation and advanced timing analysis, Signal Tap II logic analyzer, and device configuration.

To target an automotive-grade device in your design in the Intel Quartus Prime software, follow these steps:

1. Click **Assignments ➤ Device**. The **Settings** dialog box appears.
2. In the **Family** drop-down list, select your device.
3. Under **Target device**, select **Specific device selected in 'Available devices' list**.
4. In the **Available devices** list, select the appropriate ordering code.

   Note: The Intel Quartus Prime software does not show the "N" suffix, which indicates a lead-free device. For example, the 5CGXFC3B6U15A7N device is shown only as 5CGXFC3B6U15A7.
5. Click **OK**.

The following automotive-grade devices are from the legacy device families and are not recommended for new automotive designs.

- Cyclone III
- Cyclone II
- Cyclone
- MAX 7000AE

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4. Power Analysis and Estimation

4.1. Early Power Estimator

The Early Power Estimator (EPE) is a power estimation tool that helps you estimate the power consumption of your design during the system planning phase for proper power supply planning and consideration.

The EPE allows you to enter design information based on architectural features and calculates the power consumed by each architectural feature. Inputs to the EPE are environmental conditions and device resources (such as clock frequency, RAM blocks, and digital signal processing [DSP] blocks) that you expect to use in your design. The EPE then calculates the static and dynamic power, current estimates, and thermal analysis for the design.

You can either enter the design information manually into the spreadsheet or import a power estimator file of a fully or partially completed design from the Intel Quartus Prime software. After importing a file, you can edit some of the input parameters including V_{CCINT}, ambient temperature, airflow, clock frequency, and toggle percentage to suit your system requirements.

The value obtained from the EPE is only an estimation and should not be used as a specification. The accuracy of the EPE results depends on how close your input of the design information into the EPE resembles that of the final design.

For more information about the EPE, and how to generate and import the power estimator file, refer to the respective user guides.

Related Information

Early Power Estimators (EPE) and Power Analyzer, Intel page
Provides the EPE and user guides.

4.2. Power Analyzer

The Power Analyzer tool in the Intel Quartus Prime software is a power analysis tool that helps you calculate your design power consumption accurately to ensure thermal and power supply budgets are not violated after your design is complete. The Power Analyzer tool requires your design to be synthesized and fitted to the target device. Availability of information such as design resources, how the design is placed and routed on the target device, and the I/O standards assigned to each I/O cell allow the Power Analyzer tool to provide accurate power estimation.

The process of using the Power Analyzer tool consists of the following three parts:

- Specifying sources of input data
- Specifying operating conditions
- Running the Power Analyzer tool

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The input data consists of the signal activities data (toggle rates and static probabilities) of the compiled design. Signal activity data can be derived from simulation results, user assignment in the Assignment Editor, user-defined default toggle rate, and vectorless estimation.

The operating conditions include device power characteristic, ambient and junction temperature, cooling solution, and board thermal model, all of which can be set in the Intel Quartus Prime software.

The Power Analyzer tool calculates the dynamic, static and I/O thermal power consumption, current consumed from voltage source, a summary of the signal activities used for analysis, and a confidence metric that reflects the overall quality of the data sources for the signal activities.

Related Information

Power Analysis chapter, Intel Quartus Prime Standard Edition Handbook Volume 3: Verification

5. DC and Timing Specifications

The automotive-grade devices have the same values for the following specifications as published in the respective device datasheets :

- Absolute maximum ratings
- Recommended operating conditions
- DC electrical characteristics
- Timing specifications over the automotive temperature range

For the maximum power-up current (I_{CCINT}) required to power up an automotive-grade Cyclone device, use the value specified for the corresponding industrial-grade device.

The on-chip series termination (R_S OCT) specifications for the following automotive-grade devices are as follows:

- Automotive-grade Cyclone III, Cyclone IV, Cyclone V, Cyclone V SoC, Intel Cyclone 10 LP, and Intel MAX 10 devices—same as the corresponding industrial-grade devices
- Automotive-grade Cyclone II devices—same as the corresponding extended-temperature devices

The switching characteristics for the following automotive-grade devices are as follows:

- Automotive-grade Cyclone III, Cyclone IV, Cyclone V, and Cyclone V SoC devices —same as the devices with –8 speed grade as published in the respective device datasheets
- Automotive-grade MAX II and MAX V devices—same as the devices with –5 speed grade as published in the respective device datasheets

Related Information

- Intel Cyclone 10 LP Device Datasheet
- Intel MAX 10 FPGA Device Datasheet
- Cyclone V Device Datasheet
- Cyclone IV Device Datasheet
- DC and Switching Characteristics for MAX V Devices
- DC and Switching Characteristics chapter, MAX II Device Handbook
- Cyclone III Device Datasheet
- DC Characteristics and Timing Specifications chapter, Cyclone II Device Handbook
- DC and Switching Characteristics chapter, Cyclone Device Handbook
- MAX 7000A Programmable Logic Device Data Sheet

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6. Pin-Out Information

For more information about the device pin-outs, refer to the respective device pin-out files.

Related Information

Pin-Out Files for Intel FPGA Devices page

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7. Package and Board Layout Information

Intel provides information on package and PCB design guidelines.

Related Information

- Package and Thermal Resistance page, Intel website
  Provides more information about the package-related information and Package Information Datasheet for Intel Devices.
- AN 114: Board Design Guidelines for Intel Programmable Device Packages
  Provides more information about the PCB design guidelines.
- Schematic Symbols (Cadence Capture CIS and Allegro DE-HDL (Concept Software)) page
  Provides more information about designing PCBs with the Cadence OrCAD capture component information system and symbols libraries.

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A. Document Revision History for the Automotive-Grade Device Handbook

Document Version	Changes
2022.05.27	• Removed instances of "Enpirion" from *Intel Automotive-Grade Devices* section and *Intel Automotive-Grade Device Families* table. • Removed *Intel Enpirion Devices* section.
2021.03.01	Mentioned that the switching characteristics of the automotive-grade MAX II and MAX V devices are the same as the devices with –5 speed grade as published in the respective device datasheets in the *DC and Timing Specifications* section.
2019.08.27	• Updated the *Intel Automotive Qualifications* section and added Intel MAX 10 devices and the Intel Quartus Prime Standard Edition software version 17.0.2. • Corrected the Quartus software version from "Version 14.0.2 and later" to "Version 15.1.2 and later" for Intel MAX 10 devices in the *Intel Automotive-Grade Device Families* table. • Added the following devices in the *Automotive-Grade in Intel MAX 10 Devices* table. — 10M04SAE144A7G — 10M04SAU169A7G — 10M08SAE144A7G — 10M16SAE144A7G — 10M16SAU169A7G — 10M16DAF484A7G — 10M25SAE144A7G — 10M25DAF484A7G — 10M25DCF484A7G • Corrected the LE count in the *Package Options and Maximum User I/Os in MAX V Devices* table.
2018.10.01	• Updated the *Intel Automotive-Grade Devices* and *Intel Automotive Qualifications* sections. • Updated Intel Cyclone 10 devices to Intel Cyclone 10 LP devices. • Changed Enpirion to Intel Enpirion. • Removed Intel Arria® 10 devices. — Removed Intel Arria 10 devices from the *Intel Automotive-Grade Device Families* table. — Removed Intel Arria 10 devices from the *Supported Automotive-Grade Devices* section. • Updated the description for Intel MAX 10 in the *Intel Automotive-Grade Device Families* table. • Removed ES optional suffix from the *Automotive-Grade Ordering Information for Intel Cyclone 10 LP Devices* diagram. • Updated the *Automotive-Grade in Intel Enpirion® Devices*. — Replaced Device column with Maximum Output Current column. — Renamed the column Ambient Temperature Range as Ambient Operating Temperature Range. — Added the Junction Temperature Range column.

continued...

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Document Version	Changes
	• Removed the following devices from the *Automotive-Grade in Intel MAX 10 Devices* table. — 10M02SCM153A7G — 10M02DCV36A7G — 10M04SCM153A7G — 10M04DAU324A7G — 10M08DCV81A7G — 10M08DFV81A7G — 10M08SCM153A7G — 10M08DAU324A7G — 10M08DCF484A7G — 10M08DAF484A7G — 10M16DAU324A7G — 10M16DAF484A7G — 10M25DCF484A7G — 10M25DAF484A7G — 10M25DCF672A7G — 10M25DAF672A7G — 10M40DAF256A7G — 10M40DCF484A7G — 10M40DAF484A7G — 10M40DCF672A7G — 10M40DAF672A7G — 10M50DAF256A7G — 10M50DCF484A7G — 10M50DAF484A7G — 10M50DCF672A7G — 10M50DAF672A7G • Removed M153 package in the *Package Options and Maximum User I/Os in Intel MAX 10 Single Power Supply Devices* table. • Removed V36, V81, and F672 packages in the *Package Options and Maximum User I/Os in Intel MAX 10 Dual Power Supply Devices* table. • Updated the *Automotive-Grade Ordering Information for Intel MAX 10 Devices* diagram. — Removed V and M package types. — Removed WLCSP (36 and 81), MBGA (153), and FBGA (672) package types. — Removed DF feature option. • Removed notes from the following tables: — *Package Options and Maximum User I/Os in Cyclone V SE Devices* — *Package Options and Maximum User I/Os in Cyclone V SX Devices* • Removed the resource count for FBGA-896 package in 5CSXC5 device. • Updated the *Automotive-Grade in Cyclone V Devices* table. — Added 5CGXFC7D6F31A7N — Removed Cyclone V GT devices: 5CGTFD5C5U19A7N, 5CGTFD7C5U19A7N, and 5CGTFD9A5U19A7N • Removed resources for packages that are not currently available in automotive-grade for Cyclone V E and GX devices. • Updated the description for embedded hard IPs in the following diagrams: — *Automotive-Grade Ordering Information for Cyclone V E Devices* — *Automotive-Grade Ordering Information for Cyclone V GX Devices* • Removed QFN-148 package in the *Package Options and Maximum User I/Os in Cyclone IV GX Devices* table. • Removed resources for packages that are not currently available in automotive-grade for Cyclone IV E and GX devices.

Document Version	Changes
	• Updated the *Package Options and Maximum User I/Os in MAX V Devices* table. — Corrected QFP-100 to TQFP-100 and DFP-144 to TQFP-144. — Removed MBGA-64, MBGA-68, MBGA-100, and FBGA-324 packages. — Removed resources for packages that are not currently available in automotive-grade. • Updated the description for the legacy device families in the *Intel Quartus Prime Software Support* section. • Added Intel Cyclone 10 LP and Intel MAX 10 devices in the *DC and Timing Specifications* section.

Date	Version	Changes
December 2017	2017.12.15	• Removed Intel Cyclone 10 GX devices. — Removed Intel Cyclone 10 GX devices from *Automotive-Grade in Intel Cyclone 10 GX Devices* table. — Removed *Package Options and Maximum User I/Os in Intel Cyclone 10 GX Devices* table. — Removed *Automotive-Grade Ordering Information for Intel Cyclone 10 GX Devices* diagram. • Intel rebranding.
July 2017	2017.07.13	Corrected the automotive temperature range in the figure showing the available options for the Intel Arria 10 GX devices from "-40°C to 100°C" to "-40°C to 125°C".
May 2017	2017.05.08	• Updated links. • Rebranded as Intel.
February 2017	2017.02.13	• Added Intel Arria 10, Cyclone 10, and Intel Enpirion devices. • Removed PowerPlay text from tool name.
May 2016	2016.05.03	• Updated the Overview topic to remove ASIC devices. • Updated footnote in Automotive-Grade in MAX 10 Devices table. • Added new automotive-grade devices for the following device families: — MAX 10—10M08SAU169A7G — Cyclone V SoC—5CSXFC6D6F31A7N — Cyclone IV—EP4CE15U14A7N, EP4CE22U14A7N, and EP4CE55F23A7N

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Date	Version	Changes
		• Removed the following devices from Automotive-Grade in MAX 10 Devices table. — 10M04SFE144A7G — 10M04SFU169A7G — 10M04DFF256A7G — 10M04DFU324A7G — 10M08SFE144A7G — 10M08SFU169A7G — 10M08DFF256A7G — 10M08DFU324A7G — 10M08DFF484A7G — 10M16SFE144A7G — 10M16SFU169A7G — 10M16DFF256A7G — 10M16DFU324A7G — 10M16DFF484A7G — 10M25SFE144A7G — 10M25DFF256A7G — 10M25DFF484A7G — 10M25DFF672A7G — 10M40SFE144A7G — 10M40DFF256A7G — 10M40DFF484A7G — 10M40DFF672A7G — 10M50SFE144A7G — 10M50DFF256A7G — 10M50DFF484A7G — 10M50DFF672A7G • Updated the Package Options and Maximum User I/Os in Cyclone V GX Devices table. — Updated the LE count for 5CGXC3 from 31.5K LEs to 36K LEs. — Added I/Os / XCVRs count for UBGA-484 package in 5CGXC9 device. • Updated the Package Options and Maximum User I/Os in Cyclone V GT Devices table. — Added I/Os / XCVRs count for UBGA-484 package in 5CGTD9 device. • Updated the following device ordering codes diagrams: — Automotive-Grade Ordering Information for MAX 10 Devices — Automotive-Grade Ordering Information for Cyclone IV E Devices — Automotive-Grade Ordering Information for Cyclone V SE Devices — Automotive-Grade Ordering Information for Cyclone V SX Devices • Changed instances of *Quartus II* to *Quartus Prime*.
September 2014	2014.09.22	• Added MAX 10 devices. • Removed HardCopy® II devices. • Updated the Quartus II software support versions for the legacy device families. — Cyclone III—Version 8.0 to 13.1 — Cyclone II—Version 7.2 SP1 to 13.0 — Cyclone—Version 7.2 SP1 to 13.0 — MAX 7000AE—Version 7.2 SP1 to 13.0

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Date	Version	Changes
		• Added new automotive-grade devices for the following device families: — Cyclone V—5CGXFC5C6F23A7N — Cyclone IV—EP4CE40U19A7N and EP4CGX15BF14A7N — MAX V—5M40ZE64A5N, 5M80ZT100A5N, and 5M160ZT100A5N • Added Cyclone IV GX ordering information diagram. • Updated HPS I/O count for Cyclone V SE and SX devices.
September 2013	3.4	• Updated Table 3–2, Table 3–3, and Table 3–4. • Updated Figure 3–1, Figure 3–2, and Figure 3–3.
June 2013	3.3	Updated Table 3–1 and Table 3–5.
May 2013	3.2	• Updated Figure 3–2, Figure 3–3, Figure 4–1, and Figure 5–1. • Updated Table 3–1, Table 3–5, Table 4–2, Table 5–1, and Table 5–3.
February 2013	3.1	Updated Table 2-2, Table 2-3, Table 3–2, Table 3–3, Table 3–4, Table 4–2, Table 4–3, and Table 5–2.
January 2013	3.0	• Added Cyclone V and Cyclone V SoC devices. • Added Table 4–2, Table 4–3, and Table 5–2. • Updated Table 4–1, Table 4–4, Table 6–1, and Table 6–2. • Updated Figure 4–1. • Listed the following devices under legacy support: — Cyclone III — Cyclone II — Cyclone — MAX 7000A
May 2011	2.0	• Added MAX V devices. • Updated part number for Cyclone III, Cyclone IV, and HardCopy II devices. • Template conversion. • Minor text edits.
March 2010	1.2	• Added Cyclone IV devices. • Removed Referenced Documents section.
October 2008	1.1	• Updated DC and Timing Specifications section. • Converted to new template.
February 2008	1.0	Initial release.