Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors (Kernel 5.15)

Release Notes

MR7 Release

September 2023

Document Number: 732903-4.0

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Revision History

Date	Revision	Description
September 2023	4.0	• MR7 release • Intel® TCC Tools is no longer supported
March 2023	3.0	• MR6 release • Added back Intel® TCC Tools support • Intel® oneVPL replaced Intel® Media SDK which has been EOL
September 2022	2.0	• MR5 release • Added i226 and Texas Instruments (TI)* DP83867 under supported NIC/PHY
July 2022	1.1	• Updated Time-Sensitive Networking (TSN) fixed issues and workaround • Added limitations for 2.5 Gbps Auto Neg features
July 2022	1.0	• MR4 release • New feature added under List of Features for Ethernet/TSN table which is Auto Neg up to 2.5 Gbps for Marvel/Maxlinear and i225

1.0 Introduction

This document provides release information, notes, and reference for the Yocto Project*-based board support package (BSP) for the Intel Atom® x6000E Series Processors customer reference board (CRB). For instructions on how to build the Yocto Project-based image, refer to the *Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors Get Started Guide* (Document number: 619566).

Note: The version of the Yocto Project*-based build system and the corresponding open-source software components that are suggested for use with the BSP are only for reference purposes. If you decide to use Yocto Project*, you must integrate the latest functional and/or security updates when they are available from the open-source community.

1.1 Terminology

Table 1. Terminology

Term	Description
API	Application Programming Interface
APM	Advanced Power Management
AVDTP	Audio/Video Distribution Transport Protocol
A2DP	Advanced Audio Distribution Profile
BKC	Best-Known Configuration
BNEP	Bluetooth® Network Encapsulation Protocol
BSP	Board Support Package
CAN	Controller Area Network
CRB	Customer Reference Board
CV	Computer Vision
DMA	Direct Memory Access
DMIC	Digital Microphone
DRM	Direct Rendering Manager
eMMC*	Embedded Multi-Media Card
ER1	Engineering Release 1 (This Release)
eSPI	Enhanced Serial Peripheral Interface (eSPI)
ESR	Errata Service Releases

Term	Description
FMP	Find Me Profile
FW	Firmware
GAP	Generic Access Profile
GATT	Generic Attribute Profile
GbE	Gigabit Ethernet
GOEP	Generic Object Exchange Profile
GPIO	General-Purpose I/O
gPTP	generic Precision Time Protocol
HDCP	High-bandwidth Digital Content Protection
HID	Human Interface Device
IFWI	Integrated Firmware Image
I2C*	Inter-Integrated Circuit
Intel® CSE	Intel® Converged Security Engine
Intel® GNA	Intel® Gaussian & Neural Accelerator
Intel® PSE	Intel® Programmable Services Engine
Intel® TCC	Intel® Time Coordinated Computing
IoT	Internet of Things
LPSS	Low-Power Subsystem
LTS	Long-Term Support
L2CAP	Logical Link Control and Adaptation Protocol
MCAP	Multi-Channel Adaptation Protocol
mDNS	Multicast DNS
Mpps	Megapixels per second
MSI	Message Signaled Interrupt
MTU	Maximum Transmission Unit
NAP	Network Access Point
oneVPL	Intel® one Video Processing Library
OPP	Object Push Profile
PAN	Personal Area Networking
PAVP	Protected Audio Video Path
PHY	Physical Layer Device
PMC	Power Management Controller
PTP	Precision Time Protocol
PWM	Pulse Width Modulation

Term	Description
PXE	Preboot Execution Environment
QEP	Quadrature Encoder Peripheral
RPMB	Replay Protected Memory Blob
SBC	Single-board Computer
SDAP	Service Discovery Application Profile
SMP	Security Manager Protocol
SPI	Serial Peripheral Interface
SW	Software
TGPIO	Time-Aware GPIO
TSN	Time-Sensitive Networking
TSO	TCP Segmentation Offload
UART	Universal Asynchronous Receiver/Transmitter
UDP	User Datagram Protocol
UFS*	Universal Flash Storage
USB*	Universal Serial Bus
UUID	Universally Unique Identifier
VAAPI	Video Acceleration API
VPP	Video Pre-Processing

1.2 Intended Audience

This document is for users of the Yocto Project*-based BSP for the Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processor CRBs.

1.3 Customer Support

Contact your Intel representative for support or submit an issue to premiersupport.intel.com.

1.4 Reference Documents

Table 2. Reference Documents

Document	Document Number/Location
Ethernet Time-Sensitive Networking on Linux* for Intel® Processors & Ethernet Controller i225/i226 - Get Started Guide	616446
Intel® Programmable Services Engine (Intel® PSE) SDK Developer Guide	611877
Intel® Programmable Services Engine (Intel® PSE) SDK API Guide	611876
Intel® Programmable Services Engine (Intel® PSE) SDK User Guide	611827
How-to Video: Host System Build Environment Setup	608732
Intel® Programmable Services Engine (Intel® PSE) SDK Get Started Guide	608527
Host System Build Environment Setup Guide	334828
Wireless Connectivity Product for Yocto Project User Guide	617199
ECMA-393 Network Proxy Technology Support Using Linux* User Space Library (Elkhart Lake) API User Guide	613398
Programming the Intel Atom® x6000E Series Processors, Intel® Pentium® and Celeron® N and J Series Processors MAC Addresses Using Capsule Update	620481
Intel® In-Band Manageability Framework x86 Release Notes	635491
Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors Get Started Guide	619566
Elkhart Lake Platform Gold Deck	606615
Generate Key for Secure Boot with the Yocto Project*-based Image and Bootloader/UEFI BIOS	633630
Preboot Execution Environment (PXE) Boot with Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors (Code Name: Elkhart Lake) - Application Note	635874

Note: To download or search for a specific document, type the document number on the search bar on the Intel website.

2.0 Best-Known Configuration

This section shows the hardware and software compatible configuration for this release. For instructions on how to build the Yocto Project-based image, refer to the *Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors Get Started Guide* (Document number: 619566).

2.1 Hardware

- Intel Atom® x6000E Series Processors CRB (with B-1 non-FuSa Silicon or newer)
- Add-in Card: Intel® Wireless-AC 9260 (for Wi-Fi* and Bluetooth®)
- Network Interface Card with Intel® Ethernet Controller i225/i226 series

2.2 Software BKC

1. Yocto Project*-based BSP. Refer to the *Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors (Code Name: Elkhart Lake) Get Started Guide* (Document number: 619566) to download the BSP.
   - LTS kernel version: v5.15.113
   - LTS real-time kernel version: v5.15.113-rt64
   - Yocto Project* version: v4.0 LTS (Kirkstone)

   Note: This kernel source is maintained in GitHub. It is not the same source as kernel.org.

2. Firmware BKC MR7 Release: ID number: 782548
3. Proprietary Packages: *yocto_project_mr7_release.zip* (ID number: 743612). The instructions for integrating the layers are in Section 3.3.2 of the Yocto Project*-based BSP Get Started Guide (Document number: 619566).
   - meta-intel-wireless.tar.gz
   - audio_fw_mr7.zip
   - meta-libnetprox.tar.bz2
   - GNA_02.00.00.0925.7z
4. In-band Manageability Framework (ID number: 784924)
5. Intel® oneVPL (https://github.com/oneapi-src/oneVPL-intel-gpu)

6. Intel® Distribution of OpenVINO™ toolkit: openvino_2020.4.285.tar.gz (ID number: 686482)

7. Intel® SoC Watch on Yocto Project*-based Board Support Package: intel-socwatch-yoctorecipe-ver1.zip (ID number: 724016)

2.3 Summary of Newly Added Features

- For bug fixes, refer to the respective Fixed Issues sections for details. For firmware or IFWI-related bug fixes, refer to the related IFWI BKC release notes.

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3.0 Component Release Notes

3.1 BSP, I/O, Power Management, and Intel® Programmable Services Engine (Intel® PSE)

3.1.1 Introduction

This section contains general release information for I/O, power management, and host-owned Intel® Programmable Services Engine (Intel® PSE) for Yocto Project*.

3.1.2 New Features

N/A

3.1.3 Product Features

Table 3. List of BSP, I/O, Power Management, and Intel® Programmable Services Engine (Intel® PSE) Features

Feature	Summary	Availability
LPSS	UART	Yes
	I2C* controller	Yes
	SPI controller	Yes
eSPI	eSPI	Yes
GPIO	GPIO pin I/O mode	Yes
SMBus	SMBus	Yes
PMC Controller TGPIO	PMC TGPIO I/O mode	Yes
Storage/OS Boot	eMMC*	Yes/Yes
	SD* card	Yes/Not POR
	UFS*	Not POR
	USB* 3.1	Yes/Yes [1]
Host-owned Intel® Programmable Services Engine (Intel® PSE)	Intel® PSE UART RS232	Yes
	Intel® PSE UART RS485	Yes
	Intel® PSE GPIO	Yes
	Intel® PSE TGPIO	Yes
	Intel® PSE PWM	Yes
	Intel® PSE QEP	Yes

Feature	Summary	Availability
	Intel® PSE ADC	Not POR
	Intel® PSE SPI	Yes
	Intel® PSE I2C	Yes
	Intel® PSE CAN	Yes
	Intel® PSE DMA	Yes
	Intel® PSE i2s	Yes
Power Management	S0	Yes
	S3	Yes
	S4	Yes
	S5	Yes
	Warm Reset	Yes
	Cold Reset	Yes
	S0ix via suspend-to-idle	Yes
	S0ix via opportunistic idle	Yes
PXE Boot	Supports PHY – Marvell* Alaska* M 88E1512, MaxLinear* GPY115, GPY211, and GPY215 Ethernet Network Connections. (Supported Interface: SGMII for PCH GbE port, SGMII, and RGMII for PSE GbE 0 and 1)	Yes

NOTES:

1. USB Type-C Host and Device Mode are supported. For USB Type-C Device Mode to work in Elkhart Lake CRB, flash a new firmware. Refer to the CRB User Guide (Document number: 615859) for more information.
2. In this release, the new GPIO Scheme, which uses UID (Unique ID) to group the GPIO based on their community, is used. If you are using BIOS from IBV, make sure this setting (Intel Advanced Menu > PCH IO Configuration > New GPIO Scheme) is enabled to avoid boot up issue. Intel released BIOS has this setting enabled by default.

3.1.4 Known Issues

Table 4. List of BSP, I/O, Power Management, and Intel® Programmable Services Engine (Intel® PSE) Features Known Issues

Issue ID	Description
N/A	N/A

3.1.5 Fixed Issues

This section contains the list of issues that were closed from the previous release.

Table 5. List of BSP, I/O, Power Management, and Intel® Programmable Services Engine (Intel® PSE) Features Fixed Issues

Issue ID	Description
15010606811	S0ix & S3 using rtcwake alarm and other wake sources CRB is not able to resume back with i225 rev4 card connected
15010697631	With Low power s0 idle capability disabled s0ix residency is showing
15011391989	System unable to load the correct PHY when booting through IPV4/IPV6, hangs when booting through IPV6.
15013828609	PTT (fTPM2.0 Tool v4.1.1 - nvinc_master.sh) Fail on tpm2-nvincrement
18021221921	Missed kernel boot options in 5.15 bullpen RT SBL

3.1.6 Workarounds

Table 6. List of I/O and Kernel Workarounds

ID	Description
1508932757	ASPM should be enabled after Link Up. **Workaround**: Refer to the *Yocto Project*-based Board Support Package for Intel Atom® x6000E series, and Intel® Pentium® and Celeron® N and J Series Processors - Get Started Guide* (Document number: 619566) - Section 3.2 for the steps required when preparing the build.
15012119079	CAN bus communication stall for bi-directional link only. (Single direction link does not require this workaround) **Workaround**: Refer to the link on the changes that are required for this workaround. https://lore.kernel.org/lkml/20230623051124.64132-1-kumari.pallavi@intel.com/T/

3.2 Graphics/Display/Media

3.2.1 Introduction

This section contains general release information for graphics, display, and media for the Elkhart Lake CRB.

3.2.2 New Features

- N/A

3.2.3 Product Features

Table 7. List of Graphics/Display/Media Features

Feature	Description	Availability
Display/Graphics	HDMI* 1.4b/2.0a Maximum resolution: 4K@60 Hz	Yes
	eDP* 1.3 Maximum resolution: 4K@60 Hz	Yes
	DisplayPort* 1.4 Maximum resolution: 4K@60 Hz	Yes
	MIPI DSI* 1.1/1.2 Maximum resolution: 4096 x 2160 @60 Hz – **Note**: Dual-link MIPI DSI is not supported.	Yes
	Three simultaneous displays	Supports three simultaneous displays up to 4K@60Hz on each display
	LVDS [Not supported by the processor (a dongle is required)]	Validated with Chrontel* CH7511B device
	X* Server	Yes
	Weston compositor	Yes
	Mesa 3D graphics library	Yes
	OpenGL* 4.5, OpenGL* ES 3.x	Yes
	OpenCL* 1.2	Yes
	Vulkan* 1.1	Yes
	Offline Shader Compiler	No
Media	VAAPI	Yes

Feature	Description	Availability
	Hardware Video Encode/Decode (refer to Table 8)	Yes
	GStreamer media player	Yes
	Intel® oneVPL	Yes
	HDCP	No
	PAVP	No

Table 8. List of Media Codec Features

Media Codec	Format	Profile and Level	Feature Availability
Decode	H.264	Level 5.2 up to 4kp60; 8-bit; Profiles CBP, MP, HP	Yes
	MPEG2	1080p60 (MP@HL and MP@ML)	Yes
	VC-1	AP L3 (1080p30)	Yes
	H.265/HEVC	L5.1 MP up to 4kp60 (3840x2160) (Bitrate: Up to 160 Mbps); 8-bit and 10-bit L5 MP up to 4kp30 (3840x2160) (Bitrate: Up to 100 Mbps); 8-bit and 10-bit	Yes
	VP8	Up to 4kp60 (3840x2160)	Yes
	VP9	Up to 4kp60 (3840x2160); 8-bit and 10-bit	Yes
	JPEG/MJPEG	Up to 850 Mpps (YUV 4:2:0), 640 Mpps (YUV 4:2:2), 428 Mpps (YUV 4:4:4) Mpps = Megapixels per second @400 MHz. 25% Non-Zero Coefficients	Yes
Encode	H.264	Profiles MP, HP. Up to 4kp60 (3840x2160); 8-bit	Yes
	MPEG2	-	No
	VC-1	-	No
	H.265/HEVC	MP up to 4kp30 (3840x2160); 8-bit and 10-bit	Yes
	VP8	-	No
	VP9	-	No
	JPEG/MJPEG	Up to 800 Mpps (YUV 4:2:0), 600 Mpps (YUV 4:2:2) Mpps= Megapixels per second @400 MHz. 25% Non-Zero Coefficients	Yes

3.2.4 Known Issues

Table 9. List of Graphics Known Issues

Issue ID	Description
15011265944	OPENCL_fp16_math_brute_force sin, cos, sincos test fail

3.2.5 Fixed or Closed Issues

This section contains the list of issues that were closed from the previous release.

Table 10. List of Graphics Fixed or Closed Issues

Issue ID	Description
15010610408	DP1.4a CTS - Pre-Emphasis Level Delta Test & VTX MEQ DELTA (TX_EQL2/TX_EQL1) Failed

3.3 Intel® oneAPI Video Processing Library (oneVPL)

3.3.1 Introduction

Intel® oneAPI Video Processing Library (oneVPL) is a programming interface for video decoding, encoding, and processing to build portable media pipelines on CPUs, GPUs, and other accelerators. The oneVPL API is used to develop quality, performant video applications that can leverage Intel hardware accelerators. It provides device discovery and selection in media centric and video analytics workloads, and API primitives for zero-copy buffer sharing.

oneVPL is backward compatible with Intel® Media SDK and cross-architecture compatible to ensure optimal execution on current and next generation hardware without source code changes.

oneVPL is an open specification API, relevant documentation, release limitation and features, refer to the available GitHub: https://github.com/oneapi-src/oneVPL-intel-gpu

3.4 Intel® Converged Security Engine (Intel® CSE)

3.4.1 Introduction

Intel® Converged Security Engine (Intel® CSE) kernel component provides the features to support communication between Yocto Project*-based OS and Intel CSE firmware. Intel CSE supports DRM (HDCP) and proxy to RPMB residing on the storage device.

This document contains the information of the kernel configurations that are required to enable Intel CSE-dependent features. The target audiences are software vendors or customers who develop the above features on Elkhart Lake CRBs with Intel CSE support.

If Intel CSE is required, enable the kernel configuration described in Section 4.0: Appendix of Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors Get Started Guide (Document number: 619566).

Note: KDI (Kernel DAL Interface) is no longer supported from Kernel 5.15.

3.4.2 Known Issues

Table 11. List of Intel® Converged Security Engine (Intel® CSE) Known Issues

Issue ID	Description
N/A	N/A

3.5 Audio

3.5.1 Introduction

This section contains general release information for audio. Refer to the audio user guide for installation information on legacy HD Audio, i2s* audio, Intel® Gaussian & Neural Accelerator (Intel® GNA), and DMIC.

Refer to the Appendix chapter in the *Yocto Project*-based BSP Get Started Guide* (Document number: 619566) for information on how to enable audio. You will need **audio_fw_<release>.zip** (section 2.2) to enable i2s Audio via DSP.

3.5.2 New Features

- N/A

3.5.3 Product Features

Table 12. List of Audio Features

Feature	Description	Availability
Intel® Gaussian & Neural Accelerator (Intel® GNA)	Drivers, libraries, and header file	Yes
Intel® GNA plugins	Userspace, sample API in the OpenVINO™ toolkit	Yes
Legacy HD Audio (codec ALC 298) – external card	48 kHz, captured through Realtek ALC298 external audio codec	Yes
	48 kHz, played back through Realtek ALC298 external audio codec	Yes
i2s Audio via DSP (ALC 5660)	48 kHz, stereo playback through Realtek* ALC5660 onboard audio codec	Yes
	48 kHz, stereo capture through Realtek ALC5660 onboard audio codec	Yes
DMIC via DSP	Capture through the four-channel DMIC	Yes
HD Audio via DSP	Playback and record	Not POR

3.5.4 Known Issues

Table 13. List of Known Issues

Issue ID	Description
N/A	N/A

3.5.5 Fixed Issues

This section contains the list of issues that were closed from the previous release.

Table 14. List of Audio Fixed Issues

Issue ID	Description
N/A	N/A

3.6 Real Time

PREREQUISITE: Features described in this chapter will work *only* with the SKU silicon. Refer to the *Gold Deck for the Intel Atom® x6000E Series processors, Intel® Pentium® and Celeron® N and J Series Processors* (Document number: 606615) for more information on silicon type.

- Refer to the *Real Time Gold Deck* (Document number: 627170) for more information on the real time related information.
- Refer to the *Ethernet AIC Phase 2 User Guide* (Document number: 633606)

3.6.1 Time-Sensitive Networking (TSN)

3.6.1.1 Introduction

Elkhart Lake provides up to three GbE ports with TSN capabilities. The compute die has one dedicated port, while the Intel® PSE has two ports - both of which can be configured to be owned by the compute die (this ownership can also be referred to as “host-owned”). For more information, refer to the *Ethernet Time-Sensitive Networking on Linux* for Intel® Processors & Ethernet Controller i225 - Get Started Guide* (Document number: 616446).

The TSN Reference Software is a set of applications and scripts that use different Ethernet-TSN features to show the advantages of Ethernet-TSN in specific areas while educating users on specific APIs and conditions that are required. Refer to the *Ethernet Time-Sensitive Networking on Linux* for Intel® Processors & Ethernet Controller I225 - Getting Started Guide* (Document number: 616446) for further information.

Security Advisory Note:
The TSN Reference Software provided by Intel contains a Ring 3 (userspace) TC configuration application that is used to configure TSN technology parameters. The reference TC configuration application does not provide authentication for the configuration.

3.6.1.2 New Features

N/A

Refer to Section 3.6.1.3 Product Feature for more information.

3.6.1.3 Product Feature

Table 15. List of Supported PHY or NIC

Features	Description	Availability	TSN
PCIe based Ethernet Adapter	Intel® Ethernet Controller i225/i226	Yes	Yes (only -IT and -LM model)
PHY	Marvell* Alaska* M 88E1512 PHY – 10/100/1000 Mbps	Yes	Yes
	Marvell* Alaska* M 88E2110 PHY – 10/100/1000/2500 Mbps	Yes	Yes
	MaxLinear* GPY211 Ethernet Network Connection - Single-port 2.5GbED PHY – 10/100/1000/2500 GbE	Yes	Yes
	MaxLinear* GPY115 Ethernet Network Connection - Single-port 1GbE PHY for industrial applications – 10/100/100/2500 GbE	Yes	Yes
	Texas Instruments (TI)* DP83867 Ethernet Network Connection – Single-port 1GBE PHY	Yes	Yes

NOTE: Get the latest PHY firmware from PHY provider.

Table 16. List of Features for Ethernet/TSN

Domain	Features	Description	Marvell*/ MaxLinear* PHY/ Texas Instrument (TI)*PHY	Intel® Ethernet Controller i225/i226
Ethernet	MAC Core	MAC speed – 10/100/1000/2500 Mbps (Refer respective product datasheet on supported maximum speed)	Yes *For Texas Instrument (TI) * PHY - up to 1000Mbps only.	Yes

Domain	Features	Description	Marvell*/ MaxLinear* PHY/ Texas Instrument (TI)*PHY	Intel® Ethernet Controller i225/i226
		Full Duplex in multi-queue mode for all speeds	Yes	Yes
		Ethernet Bridge	Yes	Yes
		Full/Half Duplex in single-queue mode for 10/100 Mbps only	Yes	Yes
		Auto negotiation support	Yes (Up to 2.5Gbps)	Yes (Up to 2.5Gbps)
		User-configurable MTU size (9K Jumbo Support)	Yes	Yes
		Configurable multi-queue support	Yes 6 RX & 4 TX Queues	Yes 4 RX & 4 TX Queues
		Configurable RX and TX DMA ring size	Yes	Yes
		Multiple RX and TX DMA interrupt support – Message Signaled Interrupt (MSI)	Yes	Yes
		Interrupt Coalescing/Moderation	Yes	Yes
	Receive Hardware Offloading	MAC Address Filtering – Perfect/Hash/Promiscuous	Yes	Yes
		Programmable Flexible Receive Packet Parser/Filter	Yes	Yes

Domain	Features	Description	Marvell*/ MaxLinear* PHY/ Texas Instrument (TI)*PHY	Intel® Ethernet Controller i225/i226
		VLAN Filtering based VLAN ID	Yes	Yes
		VLAN Header Stripping	Yes	Yes
		Rx Frame Steering based VLAN priority	Yes	Yes
	TCP/IP Hardware Offloading	TCP Segmentation Offload (TSO)	Yes	Yes
		Checksum Offload Engine (COE) – IP, ICMP, and TCP/UDP	Yes	Yes
	Power Management	IEEE 802.3az Energy-Efficient Ethernet (EEE)	Yes Not supported for 2.5Gbps	Yes Not supported for 2.5Gbps
		Legacy PM (Sx) with D0/D3	Yes	Yes
		Low Power Mode (S0iX) with D0/D3	No	Yes
		Wake-on-LAN support – Advanced Power Management (APM)	Yes[2]	No
		Wake-on-LAN via Magic Packet support	Yes[2]	Yes
	Express Data Path (XDP)	AF_XDP socket interface with Zero-Copy Mode	Yes	Yes

Domain	Features	Description	Marvell*/ MaxLinear* PHY/ Texas Instrument (TI)*PHY	Intel® Ethernet Controller i225/i226
		Packet HW timestamping support via AF_XDP socket	Yes	Yes (AF_XDP Zero Copy only)
		Packet Transmit Time support via AF_XDP socket	Yes	Yes (AF_XDP Zero Copy only)
TSN	Time Synchronization	IEEE 802.1AS-2011 gPTP and IEEE 1588	Yes[1]	Yes[1]
		Flexible Pulse-Per-Second (PPS) output	Yes	Yes
		PTP clock timestamping triggered by external input pin (AUX_TS)	Yes	Yes
		Cross timestamping (offset between system clock and PTP clock)	Yes	Yes
	Traffic Shaping	IEEE 802.1Qav – Credit Based Shaper	Yes	Yes
		IEEE 802.1Qbv – Enhanced Scheduled Traffic	Yes	Yes
		IEEE 802.1Qbu & IEEE 802.3br – Frame Preemption	Yes[3]	Yes
		Time-Based Scheduling (Per-packet transmit time setting)	Yes	Yes
TSN Reference SW	Sample Application	Time Synchronization Quality Measurement sample application	Yes	Yes

Domain	Features	Description		Marvell*/ MaxLinear* PHY/ Texas Instrument (TI)*PHY	Intel® Ethernet Controller i225/i226
		Socket level Talker & Listener sample application		Yes	Yes
		OPC-UA level Publish-Subscriber over TSN sample application		Yes	Yes
		OPC-UA level Remote IO & Controller sample application	Single TSN Stream	Yes	Not POR
			Multiple TSN Traffic Streams	Not POR	Not POR
			Mixed Criticality Traffic Streams (single TSN Stream + Best Effort Traffic)	Yes	Not POR

NOTES:

1. If you have questions on the newer version of IEEE 802.1AS spec, contact your Intel representative.
2. Wake-on-LAN is available only if the PHY is supported. Refer to the PHY datasheet for more information. After the system waking up via Wake-on-LAN, the Ethernet connection can be checked using the ethtool.
3. IEEE 802.1Qbu & IEEE 802.3br (Frame Preemption) are available only if the PHY is supported. Refer to PHY datasheet for more information.
4. For Ti* PHY, the Run Time Power Management is not POR on EHL platform.

3.6.1.3.1 Usage Constraints

The driver pauses any transmission and reception during the transition period between AF_XDP Zero-Copy and AF_PACKET modes. For some applications such as PTP4L, a timeout or disconnection may occur during this period. After a short time, all regular traffic will resume as normal and PTP4L will re-establish connection.

When the driver is in AF_XDP Zero-Copy mode, it uses a lean code base to deliver bounded low-latency transmission and reception of packets. Because of that, users should avoid removing the driver or use it with power management features (such as suspend/resume) while the driver is in AF_XDP Zero-Copy mode.

3.6.1.4 Known Issues

Table 17. List of Known Issues for Ethernet Network Connection PHY Listed in Table 15

Issue ID	Description
N/A	N/A

Table 18. List of Known Issues for General Drivers

Issue ID	Description
N/A	N/A

Table 19. List of Known Issues for TSN Reference Software

Issue ID	Description
N/A	N/A

3.6.1.5 Fixed Issues

This section contains the list of issues that were closed from the previous release.

Table 20. List of Fixed Issues for Ethernet Network Connection PHY Listed in Table 15

Issue ID	Description
15011768146	[TI PHY] Ping failed after change speed from 1GB to 100MB after reboot and power on/off

Table 21. List of Fixed Issues for Time-Sensitive Networking

Issue ID	Description
15010645784	Failed to get 2.5Gbps link speed after running the change speed command. No longer observed this issue in EHL MR4 after enablement of 2.5Gbps auto negotiation.
15010835980	HOST showing 'unknown' speed and duplex mode after set Autoneg OFF at DUT. This is an expected and common behavior.
15011416819	S0ix failing on Network Proxy Kernel with MR4 BSP
15011460100	Data buffer (44) allocation failed after running for three hours
15013882292	Max Latency VS1 AF_XDP not meeting expected result range

3.6.1.6 Workarounds

Table 22. List of Time-Sensitive Networking (TSN) Workarounds

ID	Workaround
15011440259	Comment out `systemctl` restart **systemd-networkd.service** in **/usr/share/iotg-tsn-ref-sw/json/helpers.sh,** line 118, so that the system will not hang.

3.6.1.7 Limitations/ Observations

1. According to IEEE 802.3 Annex 127A, it is permissible for a compliant 1000BASE-X PCS (including 2.5 Gbps) transmit process to truncate the first byte of a preamble to align the start of packet on the EVEN boundary. Elkhart Lake mGBE is compliant with this clause. Some test equipment may not detect preamble truncation. Check with the equipment's vendor if you see error in packet format.
2. As shown in the table in the *Ethernet Time-Sensitive Networking on Linux* Getting Started Guide* (Document number: 616446), Section 2.4.1:

- Sub-microsecond time-sync quality is achievable for the current Intel released TSN solution (MAC and PHY) upon TX & RX latency tuning.
- For 100 Mbps to 2.5 Gbps speed, the variation of the Time Error is within 2-digit nanoseconds.
- Time Error is important to describe the quality of time-synchronization achieved through IEEE802.1AS technology. Refer to 802.1AS Recovered Clock Quality Testing for more information.

3. Make sure "VT-d" is enabled in the BIOS menu for the Ethernet driver to work.
4. Intel® Ethernet Controller I225 will be reset by igc driver each time TSN Mode is configured. This is due to scheduling packets based on time capability depends on BASET registers, which can only be written once per power cycle. This will be indicated as "reset adapter" in dmesg log.
5. 0.4% rounding error is expected for QBV running on 100 Mbps link speed. Large delay will be observed when transmitting large frame. Refer to the *GbE-TSN for Intel Atom® x6000E Series Processors, Intel® Pentium® and Celeron® N and J Series Processors Programmers Reference Manual* (Document number: 619777) for 0.4% rounding down error details.
6. Intel® Ethernet Controller i225 is validated with firmware v1.89
7. Intel® Ethernet Controller i226 is validated with firmware v2.17
8. Intel has identified an incompatibility issue on the SGMII link between the processor's GbE MAC and the supported third party PHYs identified in Table 14 List of Supported PHY or NIC, of the *Yocto Project*-based Board Support Package for Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors Release Notes* (Document number: 616424) which causes Frame Preemption (FPE) to fail. Intel has verified that the PCS (Physical Coding Sublayer)

module inside the processor's three Gigabit Ethernet (GbE) controllers is correctly encoding/decoding IEEE802.1Qbu/IEEE802.3br Merge Packets. Intel suggests that any customer encountering this incompatibility issue, contacts your third party PHY vendor for confirmation of TSN compatibility in its PHY.

9. Limitations for 2.5 Gbps Auto Neg features as follows. (Note: Also refer to Intel Atom® x6000E Series, and Intel® Pentium® and Celeron® N and J Series Processors for Internet of Things (IoT) Applications - Sighting Report (Document number: 617049) under EHL-103 14013909644: No GbE Controller Auto-negotiation at 2500Mbps)

- It is a known hardware design limitation, where the same PLL is used across the same COM lane.
- Ethernet link speed 10/100/1000M which uses the PLL clock rate, is different from 2500M. 2500M link speed is running on a 2.5x PLL clock of 10/100/1000M. Hence, 2.5 Gbps Auto Neg features will not work for two or more integrated TSN with SGMII interface that are assigned to the same COM lane.
- Make sure that the system does not have two SGMIII interface TSN GbE enabled in the same PLL Common Lane.

10. For MaxLinear GPY PHYS only, when auto-negotiation is turned OFF, the link speed will not be able to change as this is a third-party GPY limitation.

3.6.2 Intel® Time Coordinated Computing (Intel® TCC)

3.6.2.1 Introduction

Intel® Time Coordinated Computing (Intel® TCC) is a set of processor features and corresponding software that augment the compute performance of Intel processors with the ability to address the stringent temporal requirements of real-time applications. The key value is improved temporal performance for latency-sensitive applications when they are running alongside non-time-constrained applications on the same system. For more details refer to:

https://www.intel.com/content/www/us/en/developer/topic-technology/edge-5g/real-time/overview.html

3.7 Intel® Distribution of OpenVINO™ Toolkit

3.7.1 Introduction

The Intel® Distribution of OpenVINO™ toolkit is a comprehensive toolkit for quickly developing applications and solutions that emulate human vision. Based on Convolutional Neural Networks (CNNs), the toolkit extends CV workloads across Intel® hardware, maximizing performance. Refer to https://software.intel.com/en-us/openvino-toolkit/documentation/featured for various documentations and user guides. The compatible version of the toolkit can be downloaded from Document number: 621477. Copy the toolkit package to the Elkhart Lake CRB that is booted with the Yocto Project* - based BSP and should be ready for usage.

3.7.2 Known Issues (Specific to Elkhart Lake)

- N/A

3.7.3 Fixed Issues

- N/A

3.7.4 Workaround (Specific to Elkhart Lake)

Table 23. List of Intel® Distribution of OpenVINO™ Toolkit Fixed Issues (Specific to Elkhart Lake)

Issue ID	Description
N/A	N/A

3.8 Wi-Fi* and Bluetooth® Technology

3.8.1 Introduction

This section contains release information on the Wi-Fi* and Bluetooth® technology features in the Yocto Project*-based BSP for Elkhart Lake with the Intel® Wireless-AC 9260 adapter. For more information, refer to the *Wireless Connectivity User Guide* (Document number: 617199).

Refer to the *Yocto Project*-based BSP Get Started Guide* (Document number: 619566), Section 3, on how to integrate Wi-Fi* and Bluetooth® technology. You will need meta-intel-wireless.tar.gz as described in Section 2.2 of the *Get Started Guide*.

3.8.2 New Features

- N/A

3.8.3 Product Features

Table 24. List of Wi-Fi* and Bluetooth® Technology Product Features

Feature	Description	Availability
Bluetooth technology	Low Energy Low Duty Cycle Directed Advertising	Yes
	Low Energy Dual Mode Topology (Controller)	Yes
	Low Energy Link Layer Ping Mechanism	Yes
	Low Energy Link Layer Topology	Yes
	Bluetooth 4.1 Feature Requirements	Yes
	Low Energy Data Packet Length Extension	Yes
	2 Mbps Low Energy	Yes
	Limited High Duty Cycle Non-Connectable Advertising	Yes
	Low Energy Long Range	Yes
	SW RF-Kill or D3hot	Yes
	Bluetooth Specification Version 4.1 Compliance (not including optional features)	Yes
	Concurrent Bluetooth Low Energy connections (7 Low Energy Links)	Yes
	BR/EDR Multiple Connections	Yes
	Bluetooth Low Energy and BR/EDR dual-mode operation, multiple connections	Yes
	BR/EDR - Scatternet (Multirole)	Yes
	AVDTP Protocol 1.2	Yes
	RFCOMM 1.1 Protocol	Yes
Bluetooth technology	BNEP Protocol	Yes
	MCAP Protocol	Yes
	Host software support to use SBC codec in Bluetooth controller	Yes
	SBC Encoding at Host Processor	Yes
	Low Energy Dual Mode Topology Feature	Yes
	Low Energy Low Duty Cycle Directed Advertising Feature	Yes
	32-bit UUIDs for Low Energy Feature	Yes
	Common Profile and Service Error Codes	Yes
	Implement ESR 5/6/7 errata	Yes
	Fast Advertising Interval	Yes

Feature	Description	Availability
	Link Layer Topology Feature	Yes
	Low Energy Ping Feature	Yes
	BR/EDR Secure Connections Feature	Yes
	Low Energy Privacy 1.1	Yes
	Low Energy Privacy 1.2 - Extended Scanner Filter Policies	Yes
	Low Energy Secure Connection	Yes
	Low Energy Privacy 1.2 - Link Layer Privacy	Yes
	Low Energy Data Packet Length Extension	Yes
	Support ESR 8 errata	Yes
	ATT Protocol over BR/EDR	Yes
	SMP Protocol	Yes
	GATT Server	Yes
	ATT Protocol over Low Energy	Yes
	L2CAP Protocol	Yes
	Low Energy Peripheral GAP Role	Yes
	GAP Device Type (BR/EDR/Low Energy)	Yes
	Low Energy Central GAP Role	Yes
	Frequency Manager for Bluetooth	Yes
	PAN 1.0 - NAP Role	Yes
	A2DP 1.2 - Source Role	Yes
	GOEP 1.1 - Client Role	Yes
	OPP 1.1 - Push Server Role	Yes
	SDAP Profile	Yes
	HID 1.0 - Host Role	Yes
	GOEP 1.1 - Server Role	Yes
	HSP 1.2 - Audio Gateway Role	Yes
	FMP 1.0 - Find Me Target Role	Yes
	Low Energy Security Pairing Methods	Yes
	BR/EDR Secure Simple Pairing	Yes
	Bluetooth Controller Secure Boot	Yes
Bluetooth technology	Host Driver support for Secure Firmware Download	Yes
	BTDBG Bluetooth Firmware Tracing through HCI	Yes
	BTDBG HCI Tracing	Yes
	WLAN-Bluetooth coexistence.	Yes

Feature	Description	Availability
Wi-Fi technology	802.11d - Worldwide Compliance With Regulations For Use Of Wireless Signal Spectrum.	Yes
	802.11n - 40MHz Channels (Channel Bonding)	Yes
	Wake on WLAN (WoWLAN)	Yes
	Wi-Fi Direct - 5GHz 802.11n support - 40MHz channel	Yes
	Wi-Fi Direct - WFA Power Saving features	Yes
	Wi-Fi Direct - 2.4GHz 802.11g support	Yes
	Wi-Fi Direct - 5GHz 11ac support	Yes
	Platform behaves as P2P Client for P2P File Sharing.	Yes
	Wi-Fi Direct - WFA mandatory features	Yes
	Platform behaves as Group Owner for P2P File sharing	Yes
	Wi-Fi Direct - 802.11ac support	Yes
	Wi-Fi Direct - 5GHz 802.11a support	Yes
	Wi-Fi Direct - P2P Multi Client support for P2P Group Owner	Yes
	Wi-Fi Direct - 2.4GHz 11bgn support	Yes
	Wi-Fi Direct - P2P Service Discovery	Yes
	802.11ac - AP Mode	Yes
	Tethering - Routing USB* <-> WLAN	Yes
	DHCPv6 client for IPv6 network over WLAN	Yes
	IPv6 Static Address over WLAN	Yes
	connect to hidden SSID AP	Yes
	AP+STA Multirole Single Channel 5GHz	Yes
	802.11ac - Very High Throughput	Yes
	STA+P2P Multirole Single Channel 2.4GHz	Yes
	Flight Mode ON - Wi-Fi enabling	Yes
	STA+P2P Multirole Single Channel 5GHz	Yes
	AP+STA Multirole Single Channel 2.4GHz	Yes
	EAP-TTLS/MSCHAP2 – Authentication	Yes
	Wi-Fi Protected Setup* - PIN method	Yes
Wi-Fi technology	WEP – Wi-Fi Security	Yes
	Wi-Fi Protected Setup - Push Button Configuration	Yes
	EAP-TLS – Authentication	Yes
	PEAP – Authentication	Yes
	WPA2 PMF - STA privacy/forging protection	Yes
	connect to AP - enter static IP	Yes

Feature	Description	Availability
	Proxy Settings in Wireless Networks Advanced Menu	Yes
	WLAN On - Off from User Interface (via rfkill)	Yes

3.8.4 Known Issues

- N/A

3.8.5 Fixed Issues

- N/A

3.8.6 Unsupported Features

- N/A

3.9 ECMA-393 Network Proxy Technology

3.9.1 Introduction

The ECMA-393 Network Proxy service running on the Intel® PSE acts as a low-power network proxy agent to maintain the network presence for the Intel Atom® x6000E Series Processors system, when the Linux* OS that is running on a more powerful Intel® Atom enters a low-power active idle state (S0ix). The network proxy agent is designed to save power consumption by extending the Linux OS sleep time and maintain the network presence by reacting to various network protocol queries, such as IPv4 Address Resolution Protocol (ARP), IPv6 Neighbor Discovery (ND), Internet Control Message Protocol (ICMP) ping, Simple Network Management Protocol (SNMP), multicast Domain Name System (mDNS), and TCP SYNC packet in the best effort manner.

A Linux user-space network proxy library (configuration API) and sample OA application (Network Proxy Configuration Tool - netprox_app) need to be integrated from meta-libnetprox.tar.bz2 to configure the network proxy service. The Linux user-space network proxy library offers APIs to upper layer stacks or applications to interact with the network proxy agent (Intel PSE) whereas the network proxy configuration tool is a sample application that showcases how to use the APIs. Refer to the *Yocto Project*-based BSP Get Started Guide* (Document number: 619566), Section 3, on how to integrate user-space network proxy library. You will need meta-libnetprox.tar.bz2 as listed in Section 2.2.

Note: Intel expects product developers to replace the network proxy configuration tool and have its commercial stack calls into the Linux user-space network proxy library directly.

The network proxy library accesses the network proxy framework in the Linux kernel via the **configfs** interface. The **configfs** interface allows the user to read or write protocol-specific network states (handling decision or information) that are cached inside the network proxy agent (Intel® PSE).

When the Elkhart Lake system first powers-up, the network controller is enumerated and owned by the Intel Atom® processor. The Linux Ethernet driver will be loaded, and all the network activity goes through the de-facto socket interface. The network proxy framework (Intel Atom® processor) communicates with the network proxy agent (Intel® PSE) through the Inter Processor Communication (IPC) driver. When the Linux system (Intel Atom® processor) enters the S0ix power state, it will transfer the ownership of the network controller to the network proxy agent (Intel® PSE). The Ethernet driver in Intel PSE will be loaded and the network proxy agent will wait for any incoming network packet.

Refer to Section 4.3 of the *Intel® Programmable Services Engine SDK User Guide* (Document number: 611827) and Section 2.6.2 of the *Intel® Programmable Services Engine SDK Developer Guide* (Document number: 611877) for detailed information.

Disclaimer: The Network Proxy feature does not support RT Kernel.

3.9.2 Known Issues

Table 25. List of Known Issues for ECMA-393 Network Proxy Technology

Issue ID	Description
N/A	N/A

3.9.3 Fixed Issues

This section contains the list of issues that were closed from the previous release.

Table 26. List of ECMA-393 Network Proxy Technology Fixed Issues

Issue ID	Description
N/A	N/A

3.9.4 Limitations

Table 27. List of Limitations

Issue ID	Description
1509332514	When Network Proxy IPv4 is enabled with command "netprox_app -4 1", snmpd daemon needs to be restarted using command "systemctl start snmpd".

3.10 Intel® In-Band Manageability Framework

3.10.1 Introduction

Intel® In-Band Manageability Framework is a piece of software that runs on edge Internet of Things (IoT) devices and that enables users, owners, and maintainers to perform critical device management operations and over-the-air updates remotely. It also facilitates the process of publishing telemetry and critical event data, as well as logs from edge IoT devices to the cloud, thus enabling the device owner to take corrective actions when necessary. The framework is designed to be modular and flexible, ensuring scalability of the solution across a preferred cloud service provider (e.g., Azure* IoT Central, Telit* deviceWISE*, and ThingsBoard).

Refer to Document number: 635382 for the latest release package for In-Band Manageability Framework. Refer to the *Intel® In-Band Manageability Framework Release Notes* (Document number: 635491) for more details.

3.10.2 Known Issues

Table 28. List of Known Issues

Issue ID	Description
N/A	N/A

3.11 Intel® SoC Watch PnP Profiler/Debugger

3.11.1 Introduction

Intel® SoC Watch is a data collector for power-related data that can help identify issues on a platform that prevent entry to power-saving states. Captured metrics include:

- System sleep states
- CPU and GPU sleep states
- Processor frequencies
- Temperature data
- Device sleep states
- IO controller link states and latency reporting
- Platform Controller Hub activity

You can correlate the collected data and visualize over time using Intel® VTune™ Profiler.

Refer to Section 3: Getting Started with the BSP of the *Yocto Project*-based BSP Get Started Guide* (Document number: 619566), on how to integrate Intel® SoC Watch kernel module into the Yocto image. You will need *intel-socwatch-yoctorecipe-ver1.zip* (ID number: 724016) as listed in Section 2.2.

Refer to the Intel® SoC Watch Release Note for more details. Request Intel® SoC Watch NDA via this link.

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4.0 Where to Find the Release Packages and Documents

Get this release notes document from the Resource and Documentation Center by logging into your RDC account and then searching for the corresponding document number.

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