

Universal Serial Bus 4 (USB4) Device ROM Specification

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1. Introduction

The USB4 Device ROM (DROM) is a data structure located in the NVM of a USB4 product. The following USB4 products shall implement a DROM:

- A USB4 hub
- A USB4 peripheral device
- A USB4 host with a standalone add-in card (AIC) Host Router
- A USB4 host with a platform integrated Host Router may implement a DROM

The USB4 DROM provides information to the Connection Manager about the characteristics and capabilities of the USB4 product. The information in the USB4 DROM is static and configured by the Product vendor. It is expected that the silicon vendor will provide the means for the Product vendor to configure the information according to their implementation and desired identification values.

Chapters 2 through 7 define the DROM requirements for all USB4 products. Chapter 8 defines the additional DROM requirements for USB4 products that are TBT3-compatible.

Note that the requirements for a USB4 hub also apply to a USB4 Dock.

2. Access

A Connection Manager accesses the USB4 DROM through the DROM Read Router Operation. See Chapter 8 of the USB4 Specification for the definition of the DROM Read Router Operation and how it is used.

3. Bit and Byte Ordering

The data structures defined by this specification use the ordering conventions specified in this section. The order and significance of bytes are defined in terms of their relative addresses – not their physical transmission position “on the wire.”

Figure 3-1 shows the Byte and Bit ordering within a Doubleword. The most significant byte is that which has the highest address and the least significant byte is that which has the lowest address.

Figure 3-1. Byte and Bit Ordering Within a Doubleword

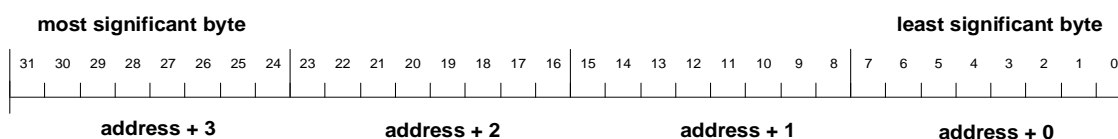
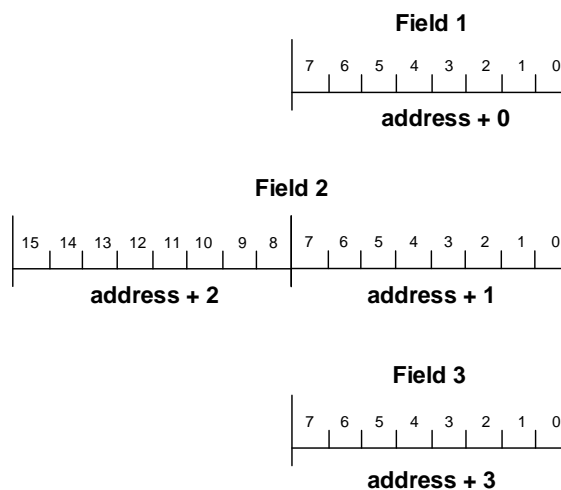


Figure 3-2 shows how multiple fields are ordered from lowest address at the top to highest address at the bottom.

Figure 3-2. Ordering of Multiple Fields



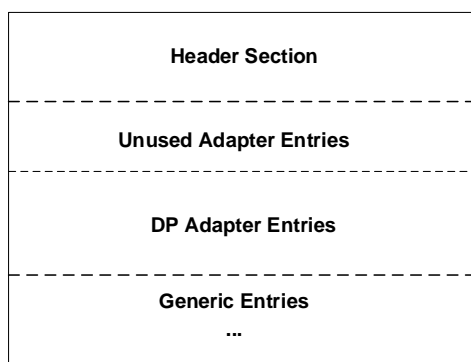
4. Format

The USB4 DROM is comprised of the following:

- Header (see Section 5)
- Adapter Entries (see Section 6)
- Generic Entries (see Section 7)

Figure 4-1 shows the high-level structure of the USB4 DROM.

Figure 4-1. USB4 DROM Structure



DROM fields that are defined as “Reserved” shall be set to zero. The value read from a “Reserved” field shall be ignored.

When “bcd” precedes the name of a field it means that the field is formatted in Binary-Coded Decimal where 0xJJMN represents version JJ.M.N (JJ – major version number, M – minor version number, N – sub-minor version number). For example, version 2.1.3 is represented with value 0213H and version 3.0 is represented with a value of 0300H.

Note: A USB4 DROM is static and does not reflect the dynamic state of the USB4 Product.

5. Header Section

The Header Section provides the basic information about the USB4 DROM. The Header Section is mandatory. Figure 5-1 shows the format of the Header Section. Table 5-1 describes the fields in the Header Section.

Figure 5-1. Header Section Format

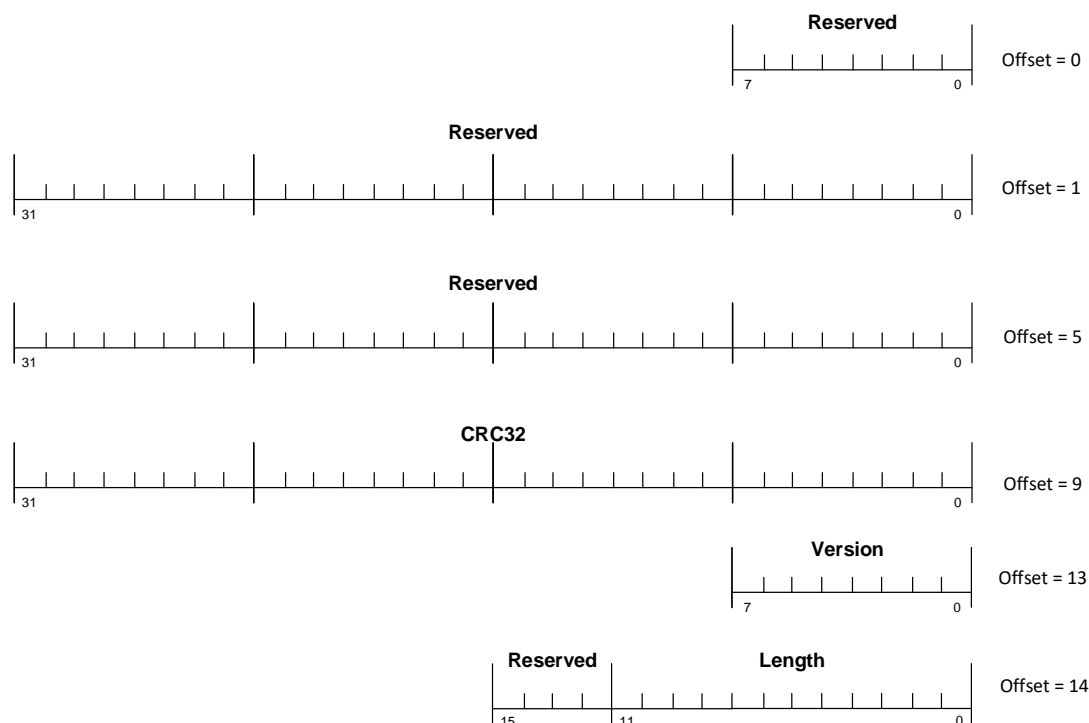


Table 5-1. Header Section Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Reserved</i>	Shall be set to 0.
1	[31:0]	<i>Reserved</i>	Shall be set to 0.
5	[31:0]	<i>Reserved</i>	Shall be set to 0.
9	[31:0]	<i>CRC32</i>	A 32-bit CRC value which protects the USB4 DROM starting from the <i>Version</i> field. The generating polynomial is $x^{32} + x^{28} + x^{27} + x^{26} + x^{25} + x^{23} + x^{22} + x^{20} + x^{19} + x^{18} + x^{14} + x^{13} + x^{11} + x^{10} + x^9 + x^8 + x^6 + 1$ with an initial value of 0xFFFFFFFF. The input bytes shall be reflected before being processed. The final value shall be reflected and then XORed with 0xFFFFFFFF. See Appendix A for example code.
13	[7:0]	<i>Version</i>	An 8-bit value that specifies to which DROM specification version this USB4 DROM conforms. This value shall be set to 3.

Offset	Bits	Field	Description
14	[11:0]	<i>Length</i>	A 12-bit value which gives the size, in bytes, of the USB4 DROM starting from the <i>Version</i> field (inclusive).
14	[15:12]	<i>Reserved</i>	Shall be set to 0.

6. Adapter Entries Section

The Adapter Entries section is optional. The Adapter Entries Section includes information about the Adapters of the Router in the USB4 product. The Connection Manager can use the information in the Adapter Entries section to decide how to best configure the Router within the USB4 product.

6.1. Unused Adapter Entry

An Unused Adapter Entry is used to describe an Adapter that is present in the hardware of a USB4 Router but is not connected to any receptacle or function in the Product. For example, when a USB4 product contains a Router that has more USB4 Ports than the device supports, the DROM for the device will have an Unused Adapter Entry for each Lane Adapter of each unused USB4 Port.

Figure 6-1 shows the format of an Unused Adapter Entry. Table 6-1 describes the fields in an Unused Adapter Entry.

Figure 6-1. Unused Adapter Entry Format

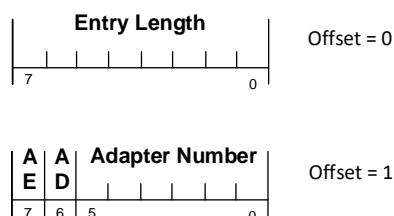


Table 6-1. Unused Adapter Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry (including the <i>Entry Length</i> field). This field shall be set to 2.
1	[5:0]	<i>Adapter Number</i>	A 6-bit value that contains the number of the Adapter in the Adapter Configuration Space of the Router.
1	[6]	<i>Adapter Disabled (AD)</i>	A bit that indicates the Adapter is disabled (if one) or enabled (if zero). This bit shall be set to 1b.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is an Adapter Entry. This bit shall be set to 1b.

6.2. DP Adapter Entry

A DP Adapter Entry describes a DP IN Adapter or a DP OUT Adapter. Figure 6-2 shows the format of a DP Adapter Entry. Table 6-2 describes the fields in a DP Adapter Entry.

Figure 6-2. DP Adapter Entry Format

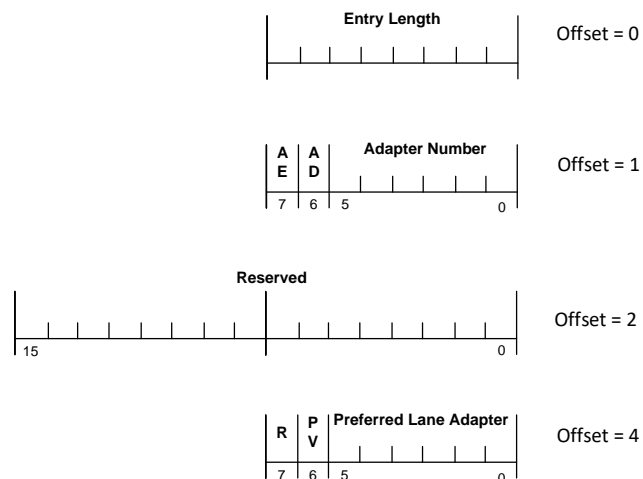


Table 6-2. DP Adapter Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry (including the <i>Entry Length</i> field). This field shall be set to 5.
1	[5:0]	<i>Adapter Number</i>	A 6-bit value that contains the address of the Adapter in the Adapter Configuration Space of the Router.
1	[6]	<i>Adapter Disabled (AD)</i>	A bit that indicates the Adapter is disabled (if one) or enabled (if zero). This bit shall be set to 0b.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is an Adapter Entry. This bit shall be set to 1b.
2	[15:0]	<i>Reserved</i>	Shall be set to 0
4	[5:0]	<i>Preferred Lane Adapter (PA)</i>	A 6-bit adapter number which identifies the Lane Adapter which is preferred when setting up a Path to this DP Adapter. This field is valid when the PV Valid is set to 1b, otherwise this field is ignored.
4	[6]	<i>Preference Valid (PV)</i>	A bit that signifies that this adapter has a preferred Lane Adapter as specified in the <i>Preferred Lane Adapter</i> field.
4	[7]	<i>Reserved</i>	Shall be set to 0

7. Generic Entries Section

7.1. Generic Entry

The Generic Entries Section provides additional Product information that is not included in the Adapter Entries Section. Figure 7-1 shows the format of a Generic Entry. Table 7-1 describes the fields in a Generic Entry.

Figure 7-1. Generic Entry Format

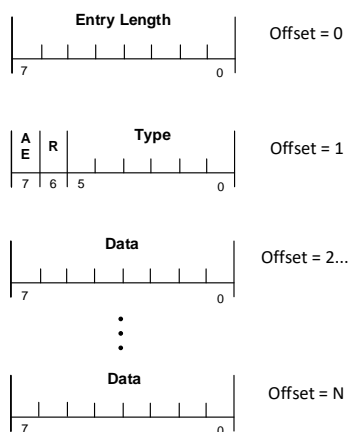


Table 7-1. Generic Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. Shall be set to N+1, where N = the Offset of the last byte of the <i>Data</i> field.

Offset	Bits	Field	Description																										
1	[5:0]	Type	<div>A 6-bit value that indicates the Generic Entry type. Connection Manager shall ignore types it does not recognize. Generic Entry types are:</div> <table><tr><td>0x0</td><td>Reserved</td></tr><tr><td>0x1</td><td>ASCII Vendor Name</td></tr><tr><td>0x2</td><td>ASCII Model Name</td></tr><tr><td>0x3 – 0x7</td><td>Reserved</td></tr><tr><td>0x8</td><td>TMU Minimum Requested Mode</td></tr><tr><td>0x9</td><td>Product Descriptor</td></tr><tr><td>0xA</td><td>Serial Number</td></tr><tr><td>0xB</td><td>USB Port Mapping</td></tr><tr><td>0xC</td><td>UTF16 Vendor Name</td></tr><tr><td>0xD</td><td>UTF16 Model Name</td></tr><tr><td>0xE – 0x2F</td><td>Reserved</td></tr><tr><td>0x30 – 0x3E</td><td>Vendor Specific Types</td></tr><tr><td>0x3F</td><td>Reserved</td></tr></table>	0x0	Reserved	0x1	ASCII Vendor Name	0x2	ASCII Model Name	0x3 – 0x7	Reserved	0x8	TMU Minimum Requested Mode	0x9	Product Descriptor	0xA	Serial Number	0xB	USB Port Mapping	0xC	UTF16 Vendor Name	0xD	UTF16 Model Name	0xE – 0x2F	Reserved	0x30 – 0x3E	Vendor Specific Types	0x3F	Reserved
0x0	Reserved																												
0x1	ASCII Vendor Name																												
0x2	ASCII Model Name																												
0x3 – 0x7	Reserved																												
0x8	TMU Minimum Requested Mode																												
0x9	Product Descriptor																												
0xA	Serial Number																												
0xB	USB Port Mapping																												
0xC	UTF16 Vendor Name																												
0xD	UTF16 Model Name																												
0xE – 0x2F	Reserved																												
0x30 – 0x3E	Vendor Specific Types																												
0x3F	Reserved																												
1	[6]	Reserved	Shall be set to 0																										
1	[7]	Adapter Entry (AE)	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.																										
2 to N N < 254	[7:0]	Data	A variably sized value that contains the data described by Type. The size of the data is equal to Entry Length minus two.																										

A USB4 DROM shall contain all of the following Generic Entries:

- An ASCII Vendor Name Entry
- An ASCII Model Name Entry
- A TMU Minimum Requested Mode Entry
- A Product Descriptor Entry

If the USB4 DROM is in a USB4 hub or Standalone AIC USB4 host, it shall also contain a USB Port Mapping Entry.

A USB4 DROM may optionally contain one or more of the following Generic Entries:

- A Serial Number Entry
- One or more UTF16 Vendor Name Entries

- One or more UTF16 Model Name Entries
- One or more Vendor Specific Entries

7.1.1. ASCII Vendor Name Entry

The ASCII Vendor Name Entry gives the company name of the USB4 product vendor. Figure 7-2 shows the format of a ASCII Vendor Name Entry. Table 7-2 describes the fields in a ASCII Vendor Name Entry.

Figure 7-2. ASCII Vendor Name Entry Format

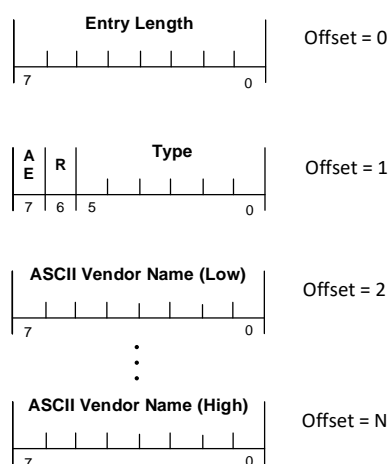


Table 7-2. ASCII Vendor Name Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. Shall be set to N+1, where N = the Offset of the last byte of the <i>ASCII Vendor Name</i> field.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0x1.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2 to N N<254	[7:0]	<i>ASCII Vendor Name</i>	The Vendor name in ASCII. Null terminated

7.1.2. ASCII Model Name Entry

The ASCII Model Name Entry provides the product model name given by the USB4 product vendor. Figure 7-3 shows the format of a ASCII Model Name Entry. Table 7-3 describes the fields in a ASCII Model Name Entry.

Figure 7-3. ASCII Model Name Entry Format

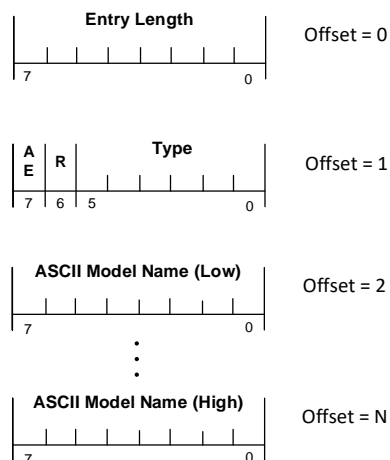


Table 7-3. ASCII Model Name Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. Shall be set to N+1, where N = the Offset of the last byte of the <i>ASCII Model Name</i> field.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0x2.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2 to N N<254	[7:0]	<i>ASCII Model Name</i>	The Model name in ASCII. Null terminated

7.1.3. TMU Minimum Requested Mode Entry

This Entry contains information about the additional time synchronization needs of the USB4 product. A Connection Manager uses this Entry to determine if the USB4 product needs its TMU configured to values other than the defaults. For example, a USB4 product with no embedded PCIe or USB 3.2 function can use the default TMU configuration and should set the *TMU Mode* to Off, but a USB4 product that uses PCIe PTM should set the *TMU Mode* to Unidirectional and the *TMU Refresh Rate* to

either HiFi or LowRes. See the CM Guide for more information on how a Connection Manager enables and configures the TMU.

Note: A Router should not request Bi-Directional, HiFi Mode Time Sync Handshakes unless it requires higher accuracy than Uni-Directional, HiFi Mode Time Sync Handshakes can provide. When Bi-Directional, HiFi Mode Time Sync Handshakes are used, a Link cannot enter CLx states.

Figure 7-4 shows the format of a TMU Minimum Requested Mode Entry. Table 7-4 describes the fields in a TMU Minimum Requested Mode Entry.

Figure 7-4. TMU Minimum Requested Mode Entry Format

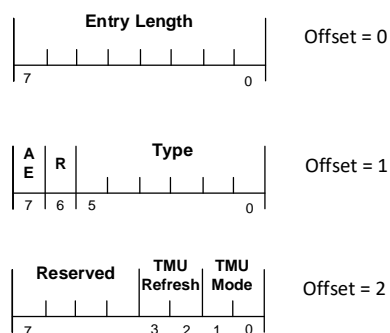


Table 7-4. TMU Minimum Requested Mode Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to 3.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0x8.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2	[1:0]	<i>TMU Mode</i>	A 2-bit value containing the preferred TMU Mode: 0 – Off 1 – Unidirectional 2 – Bidirectional 3 – Reserved

Offset	Bits	Field	Description
2	[3:2]	<i>TMU Refresh Rate</i>	<p>A 2-bit value containing the preferred TMU refresh rate:</p> <ul style="list-style-type: none"> 0 – Reserved 1 – HiFi 2 – LowRes 3 – Reserved <p>This field is only valid if the <i>TMU Mode</i> field is set to Unidirectional or Bidirectional.</p>
2	[7:4]	<i>Reserved</i>	Shall be set to 0.

7.1.4. Product Descriptor Entry

The Product Descriptor Entry provides information about the USB4 product manufacturer and the product itself. Figure 7-5 shows the format of a Product Descriptor Entry. Table 7-5 describes the fields in a Product Descriptor Entry.

Figure 7-5. Product Descriptor Entry Format

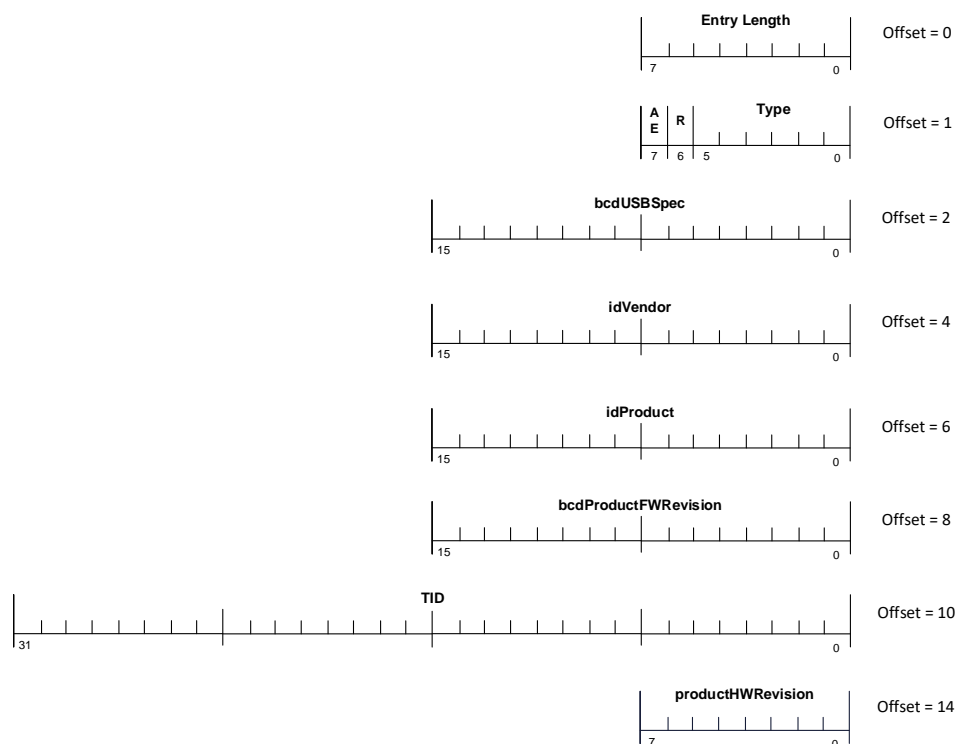


Table 7-5. Product Descriptor Entry

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to 15.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0x9.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2	[15:0]	<i>bcdUSBSpec</i>	USB Specification Version Number in binary-coded decimal (e.g., USB4 Version 1.0 is 410H). This field identifies the version of the USB Specification with which the device is compliant.
4	[15:0]	<i>idVendor</i>	This field indicates the Product Vendor ID (VID) as assigned by the USB-IF.
6	[15:0]	<i>idProduct</i>	This field indicates the Product ID (PID). This value is assigned by the vendor.
8	[15:0]	<i>bcdProductFWRevision</i>	This field indicates the Product firmware revision in binary-coded decimal. This value is assigned by the vendor. (e.g., Revision 56.78 which is decimal, will be presented as 5678h)
10	[31:0]	<i>TID</i>	This field shall contain the Test ID (TID) assigned by the USB-IF.
14	[7:0]	<i>productHWRevision</i>	This field indicates the Product hardware revision. This value is assigned by the vendor

7.1.5. Serial Number Entry

The Serial Number Entry is optional. A vendor can use this Entry to specify the Serial number of the USB4 product according to a vendor-specific scheme. Figure 7-6 shows the format of a Serial Number Entry. Table 7-6 describes the fields in a Serial Number Entry.

Figure 7-6. Serial Number Entry Format

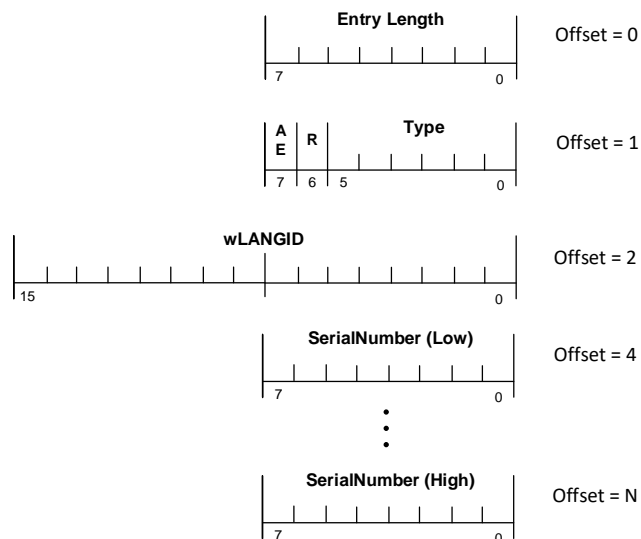


Table 7-6. Serial Number Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0xA.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2	[15:0]	<i>wLANGID</i>	A 16-bit language ID (LANGID) defined by the USB-IF. The list of currently defined USB LANGIDs can be found at: https://docs.microsoft.com/en-us/windows/desktop/intl/language-identifier-constants-and-strings .
4 to N N<254	[7:0]	<i>SerialNumber</i>	Assigned by Product Vendor. The Serial Number uses UNICODE UTF16LE encodings as defined by The Unicode Standard, Worldwide Character Encoding, Version 5.0, The Unicode Consortium, Addison-Wesley Publishing Company, Reading, Massachusetts (http://www.unicode.org).

7.1.6. USB Port Mapping Entry

The USB Port Mapping Entry is required for USB4 hubs and standalone AIC USB4 hosts. It is optional for USB4 peripheral devices and platform integrated USB4 hosts. This Entry maps the connections

between the Downstream Facing Ports of an internal USB SuperSpeed Plus host controller or internal USB SuperSpeed Plus hub to the USB3 Downstream Adapter and the USB PD controller. Figure 7-7 shows the format of a USB Port Mapping Entry. Table 7-7 describes the fields in a USB Port Mapping Entry.

Figure 7-7. USB Port Mapping Entry Format

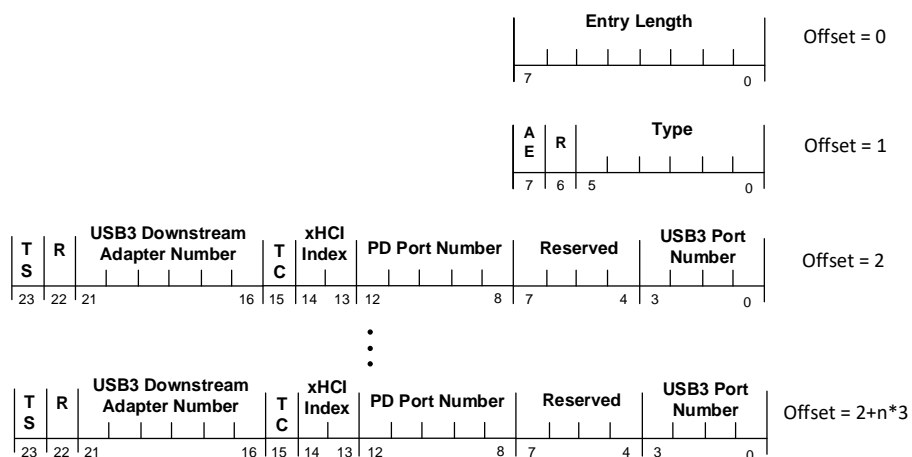


Table 7-7. USB Port Mapping Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to $2 + 3 * n$, where n is the number of DFP of the internal SuperSpeed Plus hub.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0xB.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2 to 2+n*3	[3:0]	<i>USB3 Port Number</i>	This field indicates the Downstream USB3 Port Number of the internal SuperSpeed Plus host controller or internal SuperSpeed Plus hub as defined in the USB 3.2 Specification. The rest of the fields are related to this USB3 port.
2 to 2+n*3	[7:4]	<i>Reserved</i>	Shall be set to 0.
2 to 2+n*3	[12:8]	<i>PD Port Number</i>	This field shall contain the Port Number of the USB PD controller, as defined in the USB PD Spec, which is associated with the USB Type-C connector that the USB3 port is connected to. This field is valid only if the <i>TC</i> field is set to 1b.

Offset	Bits	Field	Description
2 to 2+n*3	[14:13]	<i>xHCI Index</i>	<p>This field contains the index number of the internal SuperSpeed Plus host controller that the USB3 Port belongs to.</p> <p>This field shall be set to 0h for a Device Router DROM.</p> <p>This field shall be set to 0h if a USB4 host contains a single internal SuperSpeed Plus host controller.</p> <p>When a USB4 host contains more than one internal SuperSpeed Plus host controller, the indexing shall be 0-based and shall increment up by 1 for each additional SuperSpeed Plus host controller.</p>
2 to 2+n*3	[15]	<i>USB Type-C (TC)</i>	<p>This field shall be set to 1b if the USB3 port is connected to a USB Type-C connector. Otherwise it shall be set to 0b.</p>
2 to 2+n*3	[21:16]	<i>USB3 Adapter Number</i>	<p>This field shall contain the Adapter Number of the USB3 Adapter that is connected to the USB3 port.</p> <p>This field is valid only if the <i>TS</i> field is set to 1b.</p>
2 to 2+n*3	[22]	<i>Reserved</i>	<p>Shall be set to 0.</p>
2 to 2+n*3	[23]	<i>Tunneling Support (TS)</i>	<p>This field shall be set to 1b if the USB3 port is connected to a USB3 Adapter. Otherwise it shall be set to 0b.</p>

7.1.7. UTF16 Vendor Name Entry

The UTF16 Vendor Name Entry gives the company name of the USB4 product vendor. A USB4 product vendor can represent their company name in multiple languages by including additional UTF16 Vendor Name Entries (one Entry per language). Figure 7-8 shows the format of a UTF16 Vendor Name Entry. Table 7-8 describes the fields in a UTF16 Vendor Name Entry.

Figure 7-8. UTF16 Vendor Name Entry Format

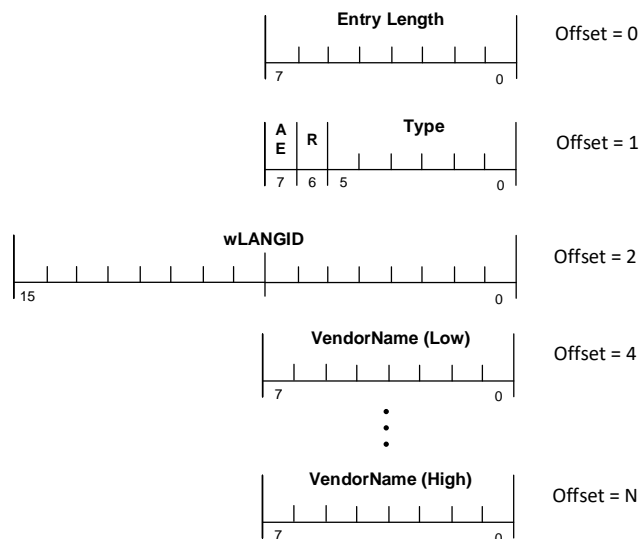


Table 7-8. UTF16 Vendor Name Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to N+1, where N = the Offset of the last byte of the <i>VendorName</i> field.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0xC.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2	[15:0]	<i>wLANGID</i>	A 16-bit language ID (LANGID) defined by the USB-IF. The list of currently defined USB LANGIDs can be found at: https://docs.microsoft.com/en-us/windows/desktop/intl/language-identifier-constants-and-strings .
4 to N N<254	[7:0]	<i>VendorName</i>	Assigned by Product Vendor. The Vendor Name uses UNICODE UTF16LE encodings as defined by The Unicode Standard, Worldwide Character Encoding, Version 5.0, The Unicode Consortium, Addison-Wesley Publishing Company, Reading, Massachusetts (http://www.unicode.org).

7.1.8. UTF16 Model Name Entry

The UTF16 Model Name Entry gives the Product name of the USB4 product. A USB4 product vendor can represent the product name in multiple languages by including additional UTF16 Model Name

Entries (one Entry per language). Figure 7-9 shows the format of a UTF16 Model Name Entry. Table 7-9 describes the fields in a UTF16 Model Name Entry.

Figure 7-9. UTF16 Model Name Entry Format

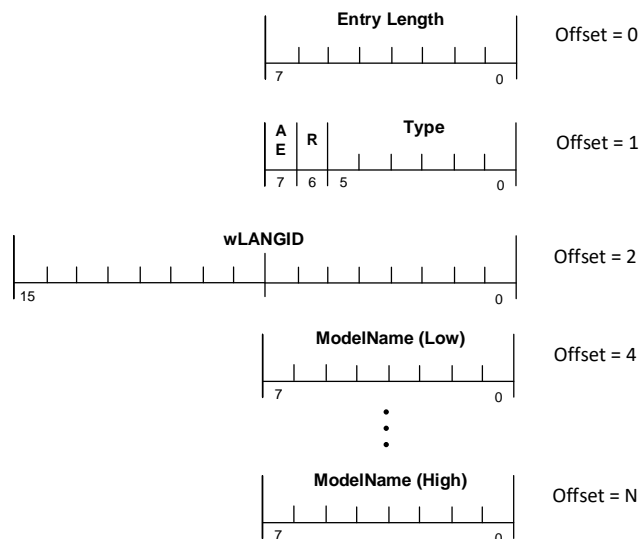


Table 7-9. UTF16 Model Name Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to N+1, where N = the Offset of the last byte of the <i>modelName</i> field.
1	[5:0]	<i>Type</i>	A 6-bit value that specifies a Generic type. This field shall be set to 0xD.
1	[6]	<i>Reserved</i>	Shall be set to 0.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is a Generic Entry. This bit shall be set to 0b.
2	[15:0]	<i>wLANGID</i>	A 16-bit language ID (LANGID) defined by the USB-IF. The list of currently defined USB LANGIDs can be found at: https://docs.microsoft.com/en-us/windows/desktop/intl/language-identifier-constants-and-strings .
4 to N N<254	[7:0]	<i>modelName</i>	Assigned by Product Vendor. The Model Name uses UNICODE UTF16LE encodings as defined by The Unicode Standard, Worldwide Character Encoding, Version 5.0, The Unicode Consortium, Addison-Wesley Publishing Company, Reading, Massachusetts (http://www.unicode.org).

8. TBT3 Compatibility

A USB4 product which is TBT3-Compatible shall implement the USB4 DROM as defined in this section. A USB4 Connection Manager is required to be able to parse both DROM versions:

- USB4 DROM, Version = 2
- USB4 DROM with TBT3-Compatibility, Version = 1

8.1. Access

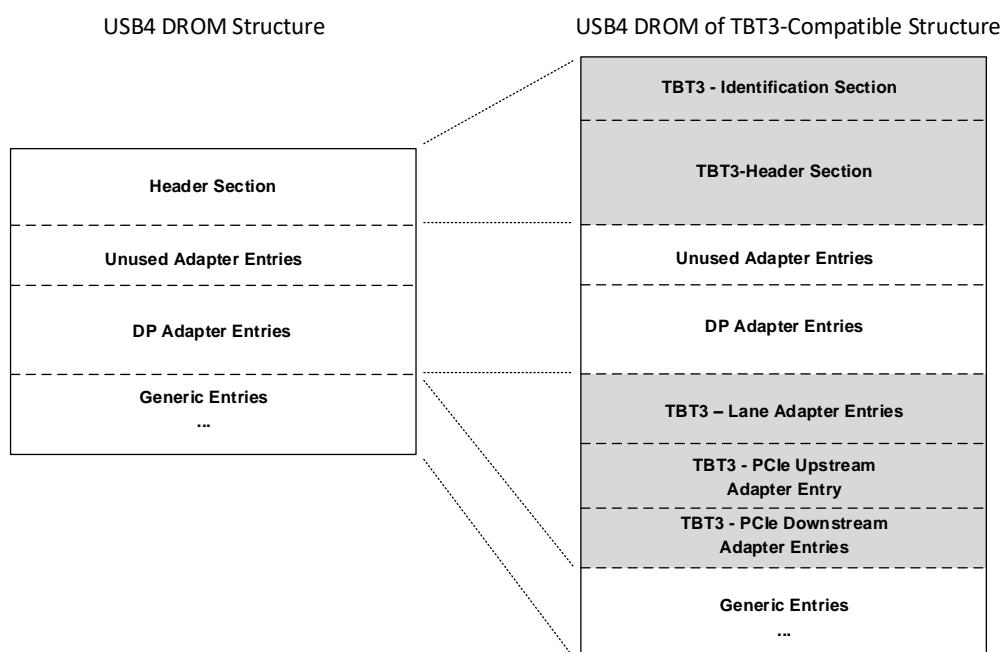
A TBT3 Connection Manager accesses the DROM using the “bit banging” mechanism, as defined in Chapter 13 of the USB4 Specification.

8.2. Format

The USB4 DROM in a TBT3-compatible USB4 product contains all the USB4 DROM construct listed in Sections 5 to 7 and in addition implements additional requirements. The following changes are applied to the USB4 DROM:

- The Header Section is replaced by TBT3-Identification Section and TBT3-Header Section described in Section 8.3 and Section 8.4 respectively
- New Adapter Entries are added, as described in Section 8.5
- Figure 8-1 illustrates the structure of both DROM versions

Figure 8-1. USB4 and TBT3-Compatible USB4 DROM Structures



8.3. TBT3-Identification Section

The TBT3-Identification section, which holds the UUID of the Router, is used by a TBT3 Connection Manager. Figure 8-2 shows the format of the TBT3-Identification Section. Table 8-1 describes the fields in the TBT3-Identification Section.

Figure 8-2. TBT3-Identification Section Format

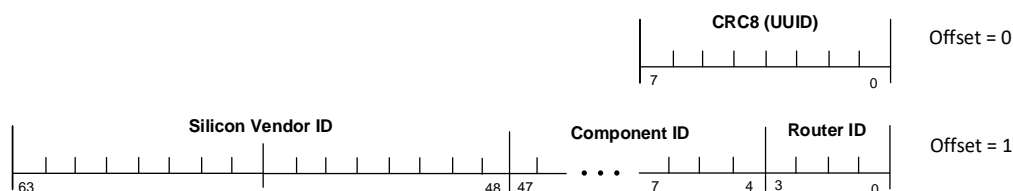


Table 8-1. TBT3-Identification Section Fields

Offset	Bits	Field	Description								
0	[7:0]	<i>CRC8</i>	An 8-bit CRC value which protects the 8 bytes of the UUID only. The generating polynomial will be $x^8 + x^2 + x + 1$ with an initial value of 0xFF. See Appendix A for example code.								
1	[63:0]	<i>UUID</i>	<p>The Universal Unique ID (UUID), as defined in the USB4 Specification.</p> <p>Shall hold the same value as the UUID in the Basic Configuration Registers of the Router Configuration Space.</p> <p>The UUID maps as follows:</p> <table><tr><td>UUID Bits</td><td>UUID Field</td></tr><tr><td>[3:0]</td><td><i>Router ID</i></td></tr><tr><td>[47:4]</td><td><i>Component ID</i></td></tr><tr><td>[63:48]</td><td><i>Silicon Vendor ID</i></td></tr></table>	UUID Bits	UUID Field	[3:0]	<i>Router ID</i>	[47:4]	<i>Component ID</i>	[63:48]	<i>Silicon Vendor ID</i>
UUID Bits	UUID Field										
[3:0]	<i>Router ID</i>										
[47:4]	<i>Component ID</i>										
[63:48]	<i>Silicon Vendor ID</i>										

8.4. TBT3-Header Section

The TBT3-Header section is used by a TBT3 Connection Manager to identify the Product vendor and model. This section is used by both USB4 and TBT3 Connection Manager, to identify the version, the length and the CRC32 of the USB4 DROM. Figure 8-3 shows the format of the TBT3-Header. Table 8-2 describes the fields in the TBT3-Header.

Figure 8-3. TBT3-Header Format

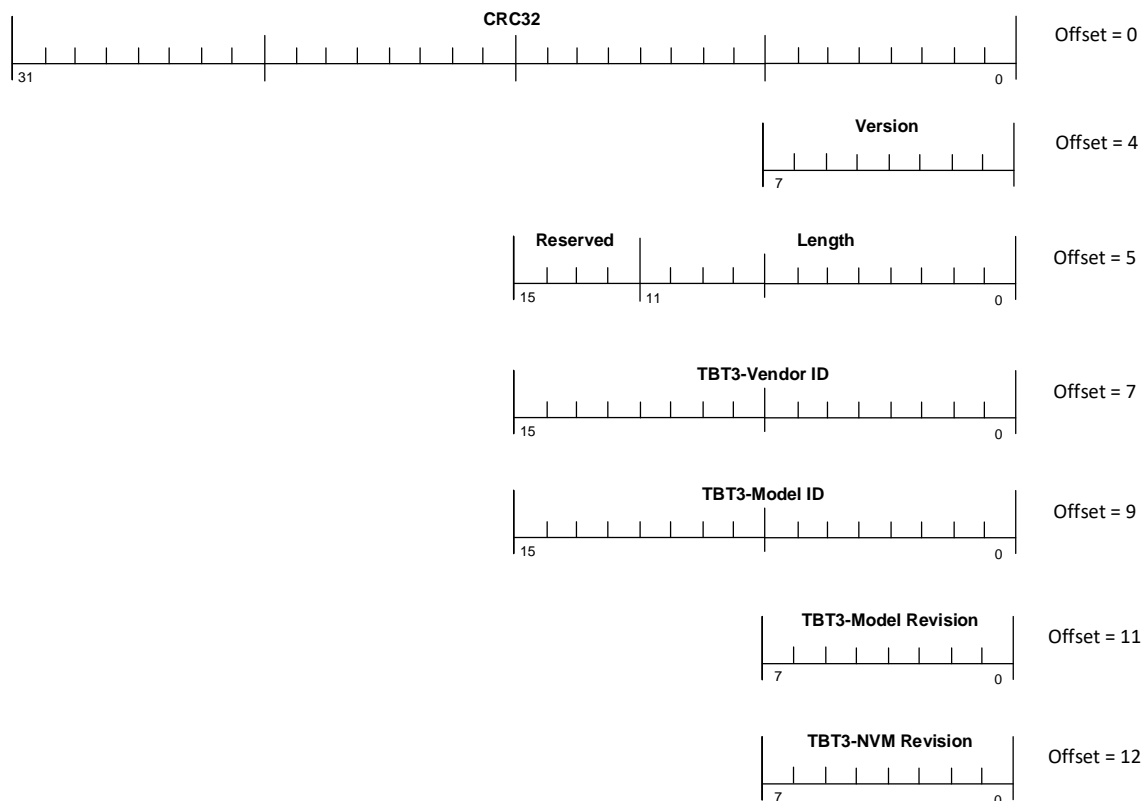


Table 8-2. TBT3-Header Fields

Offset	Bits	Field	Description
0	[31:0]	<i>CRC32</i>	A 32-bit CRC value which protects the USB4 DROM except for the Identification Section and this CRC32. The generating polynomial will be $x^{32} + x^{28} + x^{27} + x^{26} + x^{25} + x^{23} + x^{22} + x^{20} + x^{19} + x^{18} + x^{14} + x^{13} + x^{11} + x^{10} + x^9 + x^8 + x^6 + 1$ with an initial value of 0xFFFFFFFF. The input bytes shall be reflected before being processed. The final value shall be reflected and then XORed with 0xFFFFFFFF. See Appendix A for example code.
4	[7:0]	<i>Version</i>	An 8-bit value that specifies to which DROM specification version this USB4 DROM conforms. This value shall be set to 1.
5	[11:0]	<i>Length</i>	A 12-bit value which gives the size, in bytes, of the USB4 DROM starting from the <i>Version</i> field (inclusive).
5	[15:12]	<i>Reserved</i>	Shall be set to 0.
7	[15:0]	<i>TBT3-Vendor ID</i>	A 16-bit number that identifies the TBT3-vendor of this product. Assigned by Intel.

Offset	Bits	Field	Description
9	[15:0]	<i>TBT3-Model ID</i>	A 16-bit value which identifies the product line. Defined by the Product Vendor listed in the <i>TBT3-Vendor ID</i> field.
11	[7:0]	<i>TBT3-Model Revision</i>	An 8-bit value which identifies the revision of the product line; a sub categorization of the TBT3-Model ID.
12	[7:0]	<i>TBT3-NVM Revision</i>	An 8-bit value which identifies the revision of the Router NVM.

8.5. TBT3- Adapter Entries

8.5.1. TBT3-Lane Adapter Entry

A TBT3-Lane Adapter Entry is used to indicate if a Lane Adapter is a part of a Dual Lane Link. Figure 8-4 shows the format of the TBT3-Lane Adapter Entry. Table 8-3 describes the fields in the TBT3-Lane Adapter Entry.

Figure 8-4. TBT3-Lane Adapter Entry Format

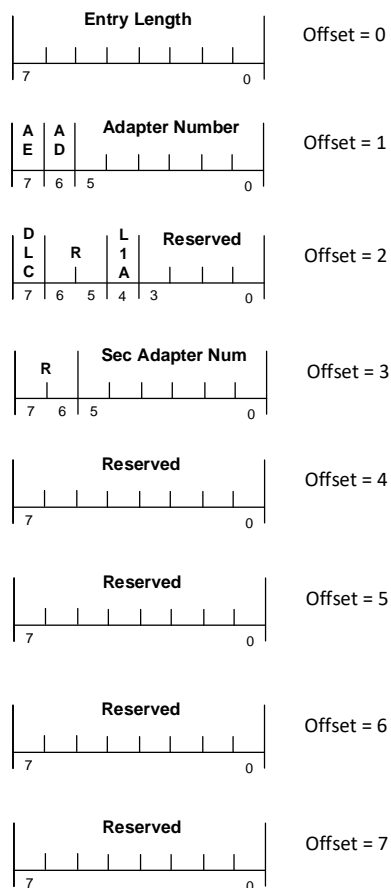


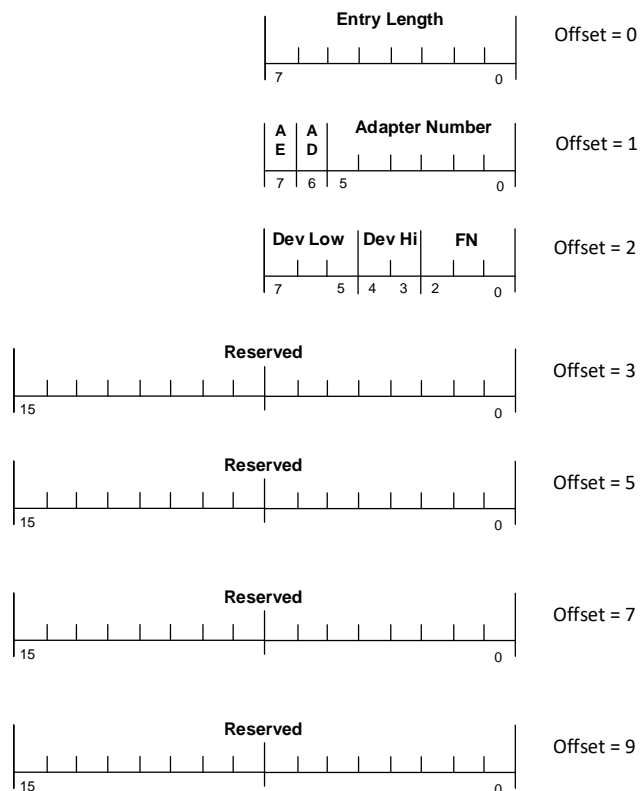
Table 8-3. TBT3-Lane Adapter Entry Format

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to 8.
1	[5:0]	<i>Adapter Number</i>	A 6-bit value that corresponds to the Adapter in the Adapter Configuration Space of the Router.
1	[6]	<i>Adapter Disabled (AD)</i>	A bit that indicates the adapter is disabled (if one) or enabled (if zero). This bit shall be set to 0b.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is an Adapter Entry. This bit shall be set to 1b.
2	[3:0]	<i>Reserved</i>	Shall be set to 0.

Offset	Bits	Field	Description
2	[4]	<i>Lane 1 Adapter (L1A)</i>	A 1-bit value that identifies if the Lane Adapter is a Lane 0 or Lane 1: 0 Lane0 1 Lane1
2	[6:5]	<i>Reserved</i>	Shall be set to 0.
2	[7]	<i>Dual-Lane Link Capable (DLC)</i>	A 1-bit value that identifies if the Lane Adapter is capable of operating in a Dual Lane link: 0 – Not Capable 1 – Capable This bit shall be set to 1b.
3	[5:0]	<i>Sec Adapter Num</i>	A 6-bits value which identifies the second Lane Adapter in the same USB4 Port.
3	[7:6]	<i>Reserved</i>	Shall be set to 0.
4	[7:0]	<i>Reserved</i>	Shall be set to 0.
5	[7:0]	<i>Reserved</i>	Shall be set to 0.
6	[7:0]	<i>Reserved</i>	Shall be set to 0.
7	[7:0]	<i>Reserved</i>	Shall be set to 0.

8.5.2. TBT3-PCIe Upstream Adapter Entry

A TBT3-PCIe Upstream Adapter Entry describes an Upstream PCIe Adapter which is connected to the Upstream Port of the PCIe Internal function within the Router. Figure 8-5 shows the format of the TBT3-PCIe Upstream Adapter Entry. Table 8-4 describes the fields in the TBT3-PCIe Upstream Adapter Entry.

Figure 8-5. TBT3-PCIe Upstream Adapter Entry Format**Table 8-4. TBT3-PCIe Upstream Adapter Entry Fields**

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to 11.
1	[5:0]	<i>Adapter Number</i>	A 6-bit value that corresponds to the Adapter in the Adapter Configuration Space of the Router.
1	[6]	<i>Adapter Disabled (AD)</i>	A bit that indicates the Adapter is disabled (if one) or enabled (if zero). This bit shall be set to 0b.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is an Adapter Entry. This bit shall be set to 1b.
2	[2:0]	<i>Function Number (FN)</i>	A 3-bit PCIe Device Function number that associates this Adapter with a Function of the PCIe Switch/Endpoint.
2	[4:3]	<i>Dev Hi</i>	A 5-bit PCIe Device number that associates this Adapter with a Device number of the PCIe Switch/Endpoint. Dev Hi shall be appended to Dev Lo as the most significant bits. Device number = {Dev Hi[1], Dev Hi[0], Dev Lo[2], Dev Lo[1], Dev Lo[0]}.
2	[7:5]	<i>Dev Lo</i>	

Offset	Bits	Field	Description
3	[15:0]	<i>Reserved</i>	Shall be set to 0.
5	[15:0]	<i>Reserved</i>	Shall be set to 0.
7	[15:0]	<i>Reserved</i>	Shall be set to 0.
9	[15:0]	<i>Reserved</i>	Shall be set to 0.

8.5.3. TBT3-PCIe Downstream Adapter Entry

A TBT3-PCIe Downstream Adapter Entry describes a Downstream PCIe Adapter which is connected to the Downstream Port of the PCIe Internal function within the Router. Figure 8-5 shows the format of the TBT3-PCIe Downstream Adapter Entry. Table 8-4 describes the fields in the TBT3-PCIe Downstream Adapter Entry.

Figure 8-6. TBT3-PCIe Downstream Adapter Entry Format

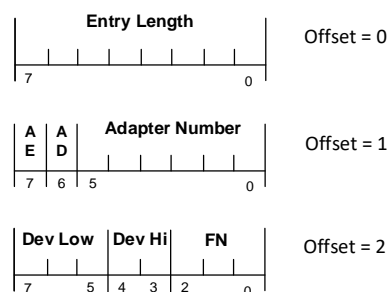


Table 8-5. TBT3-PCIe Downstream Adapter Entry Fields

Offset	Bits	Field	Description
0	[7:0]	<i>Entry Length</i>	An 8-bit value which provides the size, in bytes, of the Entry, including this field. This field shall be set to 3.
1	[5:0]	<i>Adapter Number</i>	A 6-bit value that corresponds to the Adapter in the Adapter Configuration Space of the Router.
1	[6]	<i>Adapter Disabled (AD)</i>	A bit that indicates the Adapter is disabled (if one) or enabled (if zero). This bit shall be set to 0b.
1	[7]	<i>Adapter Entry (AE)</i>	A bit that signifies this is an Adapter Entry. This bit shall be set to 1b.
2	[2:0]	<i>Function number (FN)</i>	A 3-bit PCIe Device Function number that associates this Adapter with a Function of the PCIe Switch.

Offset	Bits	Field	Description
2	[4:3]	<i>Dev Hi</i>	A 5-bit PCIe Device number that associates this Adapter with a Device number of the PCIe Switch. Dev Hi shall be appended to Dev Lo as the most significant bits. Device Number = {Dev Hi[1], Dev Hi[0], Dev Lo[2], Dev Lo[1], Dev Lo[0]}.
2	[7:5]	<i>Dev Lo</i>	

A CRC Code Examples

A.1 CRC8 Calculation

```
uint8_t ThunderboltCRC8(uint8_t * dwp, int len)
{
    uint8_t crc8 = 0xFF;
    int i;
    int b;
    for( i = 0; i < len; i++ )
    {
        crc8 ^= dwp[i];
        for( b = 0; b < 8; b++ )
        {
            if( crc8 & 0x80 )
            {
                crc8 <<= 1;
                crc8 ^= 0x07; // x^8 + x^2 + x + 1
            }
            else
            {
                crc8 <<= 1;
            }
        }
    }
    return crc8;
}
```

A.2 CRC32 Calculation

```
uint32_t CRCTABLE[256] = {
    0x00000000, 0xF26B8303, 0xE13B70F7, 0x1350F3F4,
    0xC79A971F, 0x35F1141C, 0x26A1E7E8, 0xD4CA64EB,
    0x8AD958CF, 0x78B2DBCC, 0x6BE22838, 0x9989AB3B,
    0x4D43CFD0, 0xBF284CD3, 0xAC78BF27, 0x5E133C24,
    0x105EC76F, 0xE235446C, 0xF165B798, 0x030E349B,
    0xD7C45070, 0x25AFD373, 0x36FF2087, 0xC494A384,
    0x9A879FA0, 0x68EC1CA3, 0x7BBCEF57, 0x89D76C54,
    0x5D1D08BF, 0xAF768BBC, 0xBC267848, 0x4E4DFB4B,
    0x20BD8EDE, 0xD2D60DDD, 0xC186FE29, 0x33ED7D2A,
    0xE72719C1, 0x154C9AC2, 0x061C6936, 0xF477EA35,
    0xAA64D611, 0x580F5512, 0x4B5FA6E6, 0xB93425E5,
    0x6DFE410E, 0x9F95C20D, 0x8CC531F9, 0x7EAE2FA,
    0x30E349B1, 0xC288CAB2, 0xD1D83946, 0x23B3BA45,
    0xF779DEAE, 0x05125DAD, 0x1642AE59, 0xE4292D5A,
    0xBA3A117E, 0x4851927D, 0x5B016189, 0xA96AE28A,
    0x7DA08661, 0x8FCB0562, 0x9C9BF696, 0x6EF07595,
    0x417B1DBC, 0xB3109EBF, 0xA0406D4B, 0x522BEE48,
    0x86E18AA3, 0x748A09A0, 0x67DAFA54, 0x95B17957,
    0xCBA24573, 0x39C9C670, 0x2A993584, 0xD8F2B687,
    0x0C38D26C, 0xFE53516F, 0xED03A29B, 0x1F682198,
    0x5125DAD3, 0xA34E59D0, 0xB01EAA24, 0x42752927,
    0x96BF4DCC, 0x64D4CECF, 0x77843D3B, 0x85EFBE38,
    0xDBFC821C, 0x2997011F, 0x3AC7F2EB, 0xC8AC71E8,
    0x1C661503, 0xEE0D9600, 0xFD5D65F4, 0x0F36E6F7,
    0x61C69362, 0x93AD1061, 0x80FDE395, 0x72966096,
```

```

0xA65C047D, 0x5437877E, 0x4767748A, 0xB50CF789,
0xEB1FCBAD, 0x197448AE, 0x0A24BB5A, 0xF84F3859,
0x2C855CB2, 0xDEEEDFB1, 0xCDBE2C45, 0x3FD5AF46,
0x7198540D, 0x83F3D70E, 0x90A324FA, 0x62C8A7F9,
0xB602C312, 0x44694011, 0x5739B3E5, 0xA55230E6,
0xFB410CC2, 0x092A8FC1, 0x1A7A7C35, 0xE811FF36,
0x3CDB9BDD, 0xCEB018DE, 0xDDE0EB2A, 0x2F8B6829,
0x82F63B78, 0x709DB87B, 0x63CD4B8F, 0x91A6C88C,
0x456CAC67, 0xB7072F64, 0xA457DC90, 0x563C5F93,
0x082F63B7, 0xFA44E0B4, 0xE9141340, 0x1B7F9043,
0xCFB5F4A8, 0x3DDE77AB, 0x2E8E845F, 0xDCE5075C,
0x92A8FC17, 0x60C37F14, 0x73938CE0, 0x81F80FE3,
0x55326B08, 0xA759E80B, 0xB4091BFF, 0x466298FC,
0x1871A4D8, 0xEA1A27DB, 0xF94AD42F, 0x0B21572C,
0xDFEB33C7, 0x2D80B0C4, 0x3ED04330, 0xCCBBC033,
0xA24BB5A6, 0x502036A5, 0x4370C551, 0xB11B4652,
0x65D122B9, 0x97BAA1BA, 0x84EA524E, 0x7681D14D,
0x2892ED69, 0xDAF96E6A, 0xC9A99D9E, 0x3BC21E9D,
0xEF087A76, 0x1D63F975, 0x0E330A81, 0xFC588982,
0xB21572C9, 0x407EF1CA, 0x532E023E, 0xA145813D,
0x758FE5D6, 0x87E466D5, 0x94B49521, 0x66DF1622,
0x38CC2A06, 0xCAA7A905, 0xD9F75AF1, 0x2B9CD9F2,
0xFF56BD19, 0x0D3D3E1A, 0x1E6DCDEE, 0xEC064EED,
0xC38D26C4, 0x31E6A5C7, 0x22B65633, 0xD0DDD530,
0x0417B1DB, 0xF67C32D8, 0xE52CC12C, 0x1747422F,
0x49547E0B, 0xBB3FFD08, 0xA86F0EFC, 0x5A048DFF,
0x8ECCE914, 0x7CA56A17, 0x6FF599E3, 0x9D9E1AE0,
0xD3D3E1AB, 0x21B862A8, 0x32E8915C, 0xC083125F,
0x144976B4, 0xE622F5B7, 0xF5720643, 0x07198540,
0x590AB964, 0xAB613A67, 0xB831C993, 0x4A5A4A90,
0x9E902E7B, 0x6CFBAD78, 0x7FAB5E8C, 0x8DC0DD8F,
0xE330A81A, 0x115B2B19, 0x020BD8ED, 0xF0605BEE,
0x24AA3F05, 0xD6C1BC06, 0xC5914FF2, 0x37FACCF1,
0x69E9F0D5, 0x9B8273D6, 0x88D28022, 0x7AB90321,
0xAE7367CA, 0x5C18E4C9, 0x4F48173D, 0xBD23943E,
0xF36E6F75, 0x0105EC76, 0x12551F82, 0xE03E9C81,
0x34F4F86A, 0xC69F7B69, 0xD5CF889D, 0x27A40B9E,
0x79B737BA, 0x8BDCB4B9, 0x988C474D, 0x6AE7C44E,
0xBE2DA0A5, 0x4C4623A6, 0x5F16D052, 0xAD7D5351
};

```

```

uint32_t CRC32_8( uint32_t crc, uint8_t b )
{
    int ndx = (crc ^ b) & 0xFF;
    return (crc>>8) ^ CRCTABLE[ndx];
}

```

```

uint32_t CRC32( uint32_t *dwp, int len ) {
    uint32_t crc32c = 0xFFFFFFFFL;
    uint8_t* bp = (uint8_t*)dwp;
    int i;
    for( i=0; i<len; i++ )
    {
        crc32c = CRC32_8( crc32c, bp[i] );
    }
    return crc32c ^ 0xFFFFFFFFL;
}

```

B DROM Examples**B.1 USB4 DROM Example**

Bytes (In Hex)	Field
00 00 00 00 00 00 00 00 00	Reserved
E4 80 A2 6C	CRC32
03	Version
00 66	Length
Adapter Entries	
C7 02	Unused Adapter 7
C8 02	Unused Adapter 8
41 00 00 8D 05	DP Adapter 13
41 00 00 8E 05	DP Adapter 14
Generic Entries	
00 72 6F 64 6E 65 76 20 63 69 72 65 6E 65 67 01 11	Vendor Name
00 6C 65 64 6F 6D 20 63 69 72 65 6E 65 67 02 10	Model Name
09 08 03	TMU
04 00 00 00 08 00 12 00 09 80 87 04 10 09 0F	Product Descriptor
00 34 00 33 00 32 00 31 00 2D 00 44 00 43 00 42 04 09 0A 14	Serial Number (English-US)
00 00 04 93 83 03 92 82 02 91 81 01 0B 0E	USB Ports Mapping

B.2 USB4 DROM with TBT3-Compatible Example

Bytes (In Hex)	Field
93	CRC8
80 87 1F 76 45 FD BC 00	UUID
2A 31 DA 08	CRC32
01	Version
00 BC	Length
80 87	Vendor ID
12 34	Model ID
03	TBT3-Model Revision
02	TBT3-NVM Revision
Adapter Entries	
00 00 00 00 02 80 81 08	Lane Adapter 1
00 00 00 00 01 90 82 08	Lane Adapter 2
00 00 00 00 04 80 83 08	Lane Adapter 3
00 00 00 00 03 90 84 08	Lane Adapter 4
00 00 00 00 06 80 85 08	Lane Adapter 5
00 00 00 00 05 90 86 08	Lane Adapter 6
00 00 00 00 08 80 87 08	Lane Adapter 7
00 00 00 00 07 90 88 08	Lane Adapter 8
00 00 00 00 00 00 00 20 89 0B	PCIe Upstream Adapter 9
80 8A 03	PCIe Downstream Adapter 10
80 8B 03	PCIe Downstream Adapter 11
80 8C 03	PCIe Downstream Adapter 12
41 00 00 8D 05	DP Adapter 13

Bytes (In Hex)	Field
41 00 00 8E 05	DP Adapter 14
Generic Entries	
00 72 6F 64 6E 65 76 20 63 69 72 65 6E 65 67 01 11	Vendor Name
00 6C 65 64 6F 6D 20 63 69 72 65 6E 65 67 02 10	Model Name
09 08 03	TMU
04 00 00 00 08 00 12 00 09 80 87 04 10 09 0F	Product Descriptor
00 34 00 33 00 32 00 31 00 2D 00 44 00 43 00 42 04 09 0A 14	Serial Number (English-US)
00 00 04 93 83 03 92 82 02 91 81 01 0B 0E	USB Ports Mapping