

Thunderbolt

Thunderbolt is a high-speed general-purpose data transmission technology developed by Intel in collaboration with Apple; it is one of the serial bus standards for connecting peripherals to computers developed based on Light Peak.

Development History

The data transmission channel, initially called Light Peak, was designed as a multi-protocol specification to enable data communication over various protocols such as USB, Ethernet, DisplayPort, IEEE 1394, and Fibre Channel.



Fig 1 Thunderbolt official logo

It was renamed Thunderbolt, and when it was formulated as an official standard, only PCI Express 2.0 and DisplayPort 1.1a protocols were used.

Light Peak initially planned to use optical fiber, but a standard using wire was developed and released first. The company claims to be able to communicate up to several meters with wire and several tens of meters with optical fiber.

Cable

The cable has a more powerful power supply than USB 3.0, capable of

supplying up to 10 W from the start. The connection supports daisy-chaining like SCSI and IEEE 1394, and up to six peripherals can be connected to one port on the host side. The connector shape was the same as that of Mini DisplayPort until Thunderbolt 2.

The Thunderbolt 3 connector uses a USB Type-C connector, which has a maximum power supply capacity of 100 W in Thunderbolt 3, compared to a maximum of 10 W in Thunderbolt 2.

Transfer Rate

The data transfer rate is 10 Gbps full-duplex for both uplink and downlink. The signal level transfer rate is 10.3125 Gbps, encoded in 64b/66b with an actual data transfer rate of 10 Gbps. In the bidirectional mode, two lanes support up to 20 Gbps.

Translated with



Fig 2 Thunderbolt Cable

Standard

Thunderbolt

Thunderbolt was first used in Apple's Macbook Pro (Early 2011), which was announced and released in February 2011, and was later installed in iMac, Mac mini, and other devices. The connector uses Mini DisplayPort.

Thunderbolt 2

In late 2013, Intel introduced Thunderbolt 2,

which aggregates two channels to achieve a transfer rate of 20 Gbps. Mac Pro on December 19, 2013. The connector uses Mini DisplayPort as in Thunderbolt 1 to ensure backward compatibility. Compatible fiber-optic cables up to 30 meters and 60 meters are available from Sumitomo Electric Industries and Corning, respectively.

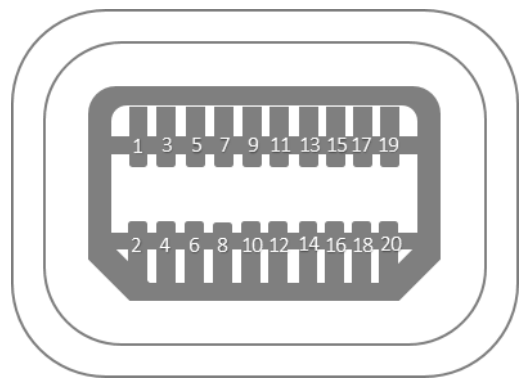
Thunderbolt 3

Thunderbolt 3, which uses a USB Type-C connector and achieves a transfer rate of 40 Gbps, was announced in June 2015; Apple released a MacBook Pro with Thunderbolt 3 on October 28, 2016. It is backward compatible with Thunderbolt and Thunderbolt 2, but due to the different connector geometry, a conversion adapter is required for backward compatible use.

The 40 Gbps transfer rate is the sum of the bandwidth for video and data, and the bandwidth available for data transfer is limited to 22 Gbps. In some systems, the controller and CPU are connected by two lanes of PCI Express 3.0, in which case the maximum data transfer rate is 16 Gbps. Note that Intel described the data transfer bandwidth of Thunderbolt 3 as 16 Gbps in

conjunction with the launch of Thunderbolt 4, described below, but a slide published in 2016 shows 22 Gbps, and the reason for this difference is unclear.

Table 1 Pin out



Pin 1	GND
Pin 2	HPD
Pin 3	HS0TX(+)
Pin 4	HS0RX(+)
Pin 5	HS0TX(-)
Pin 6	HS0RX(-)
Pin 7	GND
Pin 8	GND
Pin 9	LSR2P TX
Pin 10	GND
Pin 11	LSP2R RX
Pin 12	GND
Pin 13	GND
Pin 14	GND
Pin 15	HS1TX(+)
Pin 16	HS1RX(+)
Pin 17	HS1TX(-)
Pin 18	HS1RX(-)
Pin 19	GND
Pin 20	DPPWR

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