

Maximum Packet Rates for Full-Duplex Ethernet

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Abstract

This technical report calculates the maximum packet rates for 10Mb/s, 100Mb/s, and 1Gb/s full-duplex Ethernet from the parameters in the IEEE 802.3 specification [1].

1 Introduction

To determine the behavior of systems built with Ethernet technology, we often would like to subject our system (or its model) to worst-case traffic. The generally means the maximum packet rate for a given packet size. The IEEE specification for Ethernet [1] does not explicitly provide these values. This technical report uses the parameters in the specification to determine these values analytically.

The scope of this technical report is limited to full-duplex 10Mb/s (e.g., 10 BASE-T), 100Mb/s (e.g., 100 BASE-T), and 1 Gb/s (e.g., 1000 BASE-T) Ethernet.

1.1 Definitions

MAC	Media Access Controller.
Preamble Field	A pattern of alternating zero and one bits used to synchronize the receiver clock to the incoming packet.
SFD Field	Start Frame Delimiter Field. A specific bit pattern which indicates the beginning of a frame.
FCS Field	Frame Check Sequence. A cyclic redundancy check based on the source address, destination address, length/type, and data/pad fields of the MAC frame.

2 Min/Max Packet Sizes

Table 1 lists the fields which make up an Ethernet MAC frame for a full-duplex link. (On a half-duplex links faster than 100Mb/s an extension field may be required.) If the data is less than 46 octets in length, it must be padded to 46 octets. From the table we see that for a full-duplex link, an Ethernet frame is between 72 and 1526 octets in length. (The commonly cited range of 64 to 1518 octets does not include the Preamble or SFD fields which are usually automatically generated by the Ethernet hardware.) Since there are 8 bits per octet, Ethernet frames range from 576 bits to 12,208 bits in length.

Field	Size (Octets)	
	Minimum	Maximum
Preamble	7	7
SFD	1	1
Destination Address	6	6
Source Address	6	6
Length/Type	2	2
Data/Pad	46	1500
FCS	4	4
Total	72	1526

Table 1: Full-Duplex Ethernet MAC Frame Format. (From Figure 3–1 of [1].)

3 Packet Rates

Ethernet uses a bit-serial transmission scheme where the bit rate is 10, 100, or 1000 Mb/s. The bit time (time per bit) is the reciprocal of the bit rate. Under full-duplex operation, there are no collisions and hence each packet requires a time on the wire equal to the number of bits in the packet times the bit time.

In addition to the packet time-on-the-wire, there must be a gap between each packet. That is, packets cannot be transmitted back-to-back. The IEEE specification calls this parameter the interFrameGap. While not defined in terms of bit times, interFrameGap happens to be 96 bit times in duration for 10 Mb/s, 100 Mb/s, and 1 Gb/s Ethernet. Table 2 lists the durations (in bit times) for the minimum and maximum packet sizes. From this table we see, for example, that the time from the start of a minimum sized packet to the start of the next packet is 672 bit times. This also means that the time from the end of a packet to the end of the next (minimum sized) packet is 672 bit times.

	Duration (Bit Times)	
	Minimum-size Packets	Maximum-size Packets
Packet Time	576	12208
interFrameGap	96	96
Packet Start-to-Start	672	12304

Table 2: Packet Duration Times for Full-Duplex Ethernet

We calculate the packet rate for each Ethernet type by dividing the bit rate by the packet start-to-start time. Table 3 summarizes the packet rates and data rates. The data rate is the packet rate multiplied by the number of “data bits” per packet. For the purposes of calculating data rates, we include the destination address, source address, length/type, data/pad, and the FCS fields in the definition of “data bits.” For intermediate sized packets with n “data bits” per packet, the packet rate, R_p , and the data rate, R_d , are given by:

$$R_p = R_b / (56 + 8 + n + 96) \quad R_d = R_p \times n$$

where R_b is the bit rate.

	Minimum-size Packets		Maximum-size Packets	
	Packet Rate	Data Rate*	Packet Rate	Data Rate*
10 Mb/s Ethernet	14.88 Kpps	7.62 Mb/s	0.813 Kpps	9.87 Mb/s
100 Mb/s Ethernet	148.8 Kpps	76.2 Mb/s	8.13 Kpps	98.7 Mb/s
1 Gb/s Ethernet	1488. Kpps	762. Mb/s	81.3 Kpps	987. Mb/s

* Ethernet MAC frame excluding the Preamble and the SFD.

Table 3: Packet and Data Rates for Full-Duplex Ethernet

4 Summary

Table 4 summarizes the worst-case (requiring the most processing) parameters for full-duplex Ethernet. The minimum end-to-end time is the minimum amount of time from the end of a packet to the end of the next packet. For processors or devices which handle packets serially and without buffering, this is the maximum amount of time the processor or device is guaranteed before the next packet arrives.

Parameter	10 Mb/s Ethernet	100 Mb/s Ethernet	1 Gb/s Ethernet	Notes
Max. Packet Rate	14.88 Kpps	148.8 Kpps	1488. Kpps	Min size packets
Max. Data Rate*	9.87 Mb/s	98.7 Mb/s	987. Mb/s	Max size packets
Min. End-to-End Time	67.2 μ s	6.72 μ s	672. ns	

* Ethernet MAC frame excluding the Preamble and the SFD.

Table 4: “Line-Speed” Parameters for Full-Duplex Ethernet

References

- [1] IEEE Standard 802.3. *Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*. IEEE, New York, NY, October 2000.