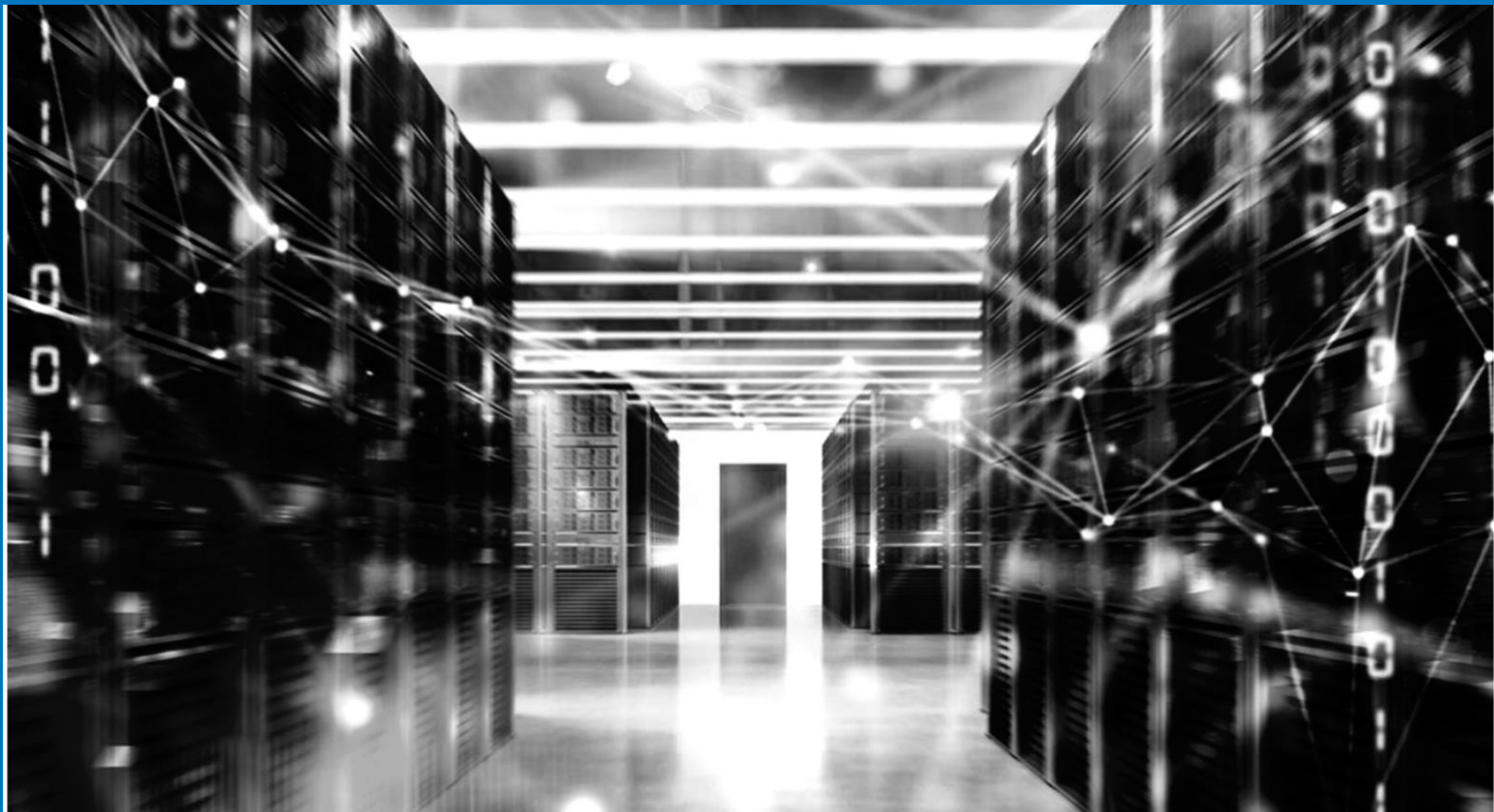


Measuring frame Delay Variation (Jitter)



APPLICATION NOTE

How to measure FDV accurately and in real time using Teledyne LeCroy Xena testers.

With the increasing use of delay sensitive media services over IP and Ethernet networks, understanding the frame delay variation (FDV) characteristics of these networks and network devices has become more important. This application note describes how FDV is measured accurately and in real time with Teledyne LeCroy Xena testers.

Defining Frame Delay Variation

The definition of Frame Delay Variation (FDV) is the absolute value of the difference between the Forwarding Delay of two consecutive received packets belonging to the same stream. Other notations commonly used are Packet Delay Variation, or simply "Jitter".

For example, when two packets (packets A and B) are sent through a network where packet A takes 10 ms to traverse the network, and packet B takes 12 ms to traverse the network, the difference in latency between the two packets is 2 ms, and $FDV = |12 - 10| = 2$ ms.

If A is the first packet and B is the second packet, then FDV can be expressed as:

$$FDV = |(RxA - TxA) - (RxB - TxB)| = |(TxB - TxA) - (RxB - RxA)|$$

So, the calculation of FDV requires the following four parameters:

- Timestamp of second transmitted packet
- Timestamp of first transmitted packet
- Timestamp of second arriving packet
- Timestamp of first arriving packet

If the packet latency is constant, then FDV is zero since the difference in latency does not change from packet to packet.

It should be noted that FDV is *not* equal to the difference between the maximum packet latency and minimum packet latency over a given period of time, since this latency range does not reflect a measured frame-to-frame delay variation, and also because changes in latency over time (such as an increasing latency) may not affect the FDV, such as when for example the latency through a device steadily increase from 10 ms to 100 ms over the period of the test, in which case the latency range is 80 ms which is most likely far higher than the actual FDV.

Measuring FDV using IFG histograms

The Inter Frame Gap (IFG) histogram method is a well-known method for measuring FDV. It requires that the packets are transmitted with a fixed and known Inter Frame Gap (IFG), so that only the IFG of the received packets must be measured and displayed in a histogram. Since the difference in the IFG between received packets is equal to the FDV, it is possible to determine the approximate maximum, minimum and average FDV by analyzing the Rx IFG Histogram.

This method does however have limitations, lack of accuracy, and multiple flaws. The primary limitation is that packets must be sent at equal intervals, which restricts the FDV measurement to uniform traffic patterns only. This in turn, makes it impossible to measure FDV on varying rate (bursty) traffic patterns.

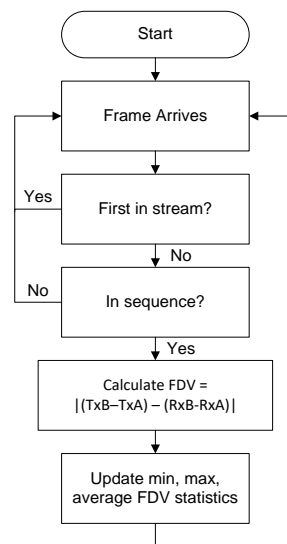
The IFG histogram will show how many packets were received in each IFG bucket, but cannot produce any detailed analysis such as a FDV histogram or how the FDV occurred over time, since all that can be determined from the Rx IFG histogram are the maximum, minimum and average FDV.

An important flaw of the IFG histogram method is that a packet loss will corrupt the FDV results. This is because the packets before and after the lost packet will corrupt the maximum FDV value that can be deducted from the IFG histogram, because these packets will indicate an erroneously high FDV value due to the dropped packet. Similar, when packet arrive out-of-order, this will also corrupt the FDV results which can be deducted from the Rx IFG histogram.

Measuring FDV according to MEF 10

In contrast, true real-time FDV measurement at high resolution requires specialized hardware that accurately processes the data in real time at line rates of 1, 10, 40 and 100 Gbps, and measures FDV with 8 ns accuracy.

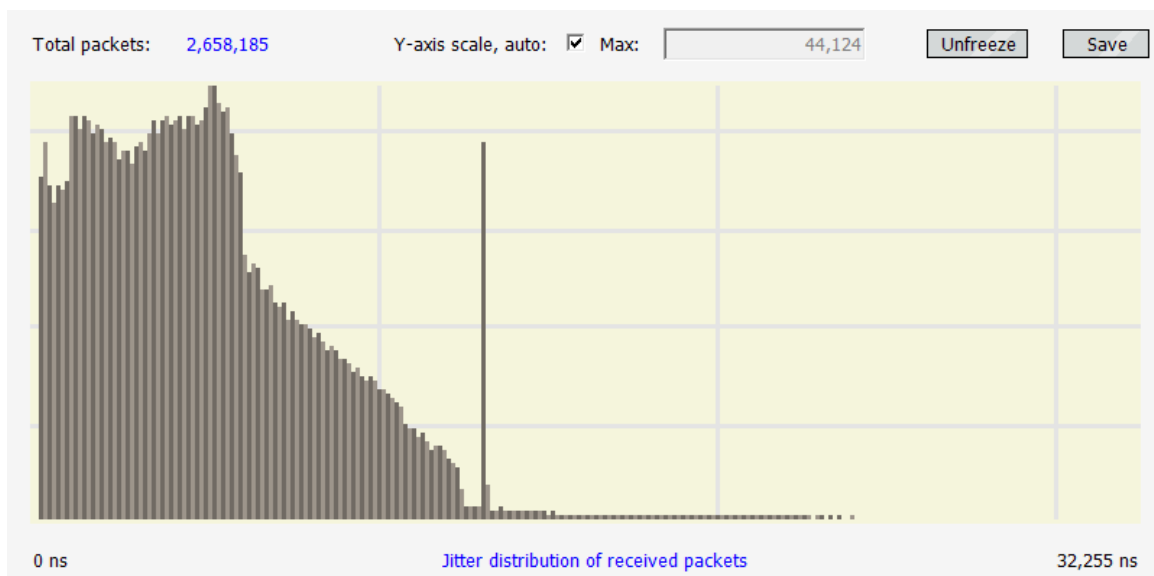
The Metro Ethernet Forum released the MEF 10 specification in 2004 defining how to measure frame delay variation (FDV). The flow chart in Figure 1 illustrates how the MEF 10 specification is implemented accordingly in the Teledyne LeCroy Xena testers, running at line rates up to 100 Gbps.



▪ Figure 1 MEF 10 frame delay variation (FDV) measurement implementation

The main advantages of the MEF 10 real time FDV measurement is that the packets can be sent with any uniform or bursty traffic pattern, unlike the IFG histogram method which requires that the packets are transmitted with a fixed and known Inter Frame Gap (IFG). Furthermore, this method compensates for lost and out-of-sequence packets, and it provides real-time FDV statistics reflecting dynamic changes in traffic or device device parameters.

Another advantage of real-time jitter measurement is that it includes analysis views such as FDV (jitter) histograms, which provides a comprehensive and accurate view of the exact jitter distribution, such as shown in Figure 2 , thereby reducing test and analysis time.



▪ Figure 2 Real time FDV (Jitter) histogram