# Network Synchronization Technologies Poster

## Synchronization Standards

| | ITU-T | ETSI |
|---|---|---|
| PRC | G.811 | EN 300 462-6-1 |
| SSU/BITS | G.812 | EN 300 462-4-1 |
| SONET/SDH Equipment Clock | G.813 | EN 300 462-5-1 |

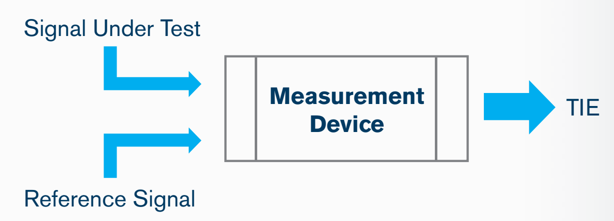
| Types of Synchronization | |
|---|---|
| Time synchronization | Devices synchronized to the same time information |
| Frequency synchronization | Devices having the same number of bits over a period of time |
| Phase synchronization | Devices will shift exactly at the same time from one clock pulse to another |

### Acronyms

| | | | | | |
|---|---|---|---|---|---|
| **BITS** | Building integrated timing supply | **GPS** | Global positioning system | **SEC** | SONET/SDH equipment clock |
| **EEC** | Ethernet equipment clock | **MTIE** | Maximum time interval error | **SSU** | Synchronization supply unit |
| **ESMC** | Ethernet synchronization messaging channel | **PRC** | Primary reference clock | **SyncE** | Synchronous Ethernet |
| | | **PRS** | Primary reference source | **TDEV** | Time deviation |
| | | **PTP** | Precise time protocol | **TIE** | Time interval error |

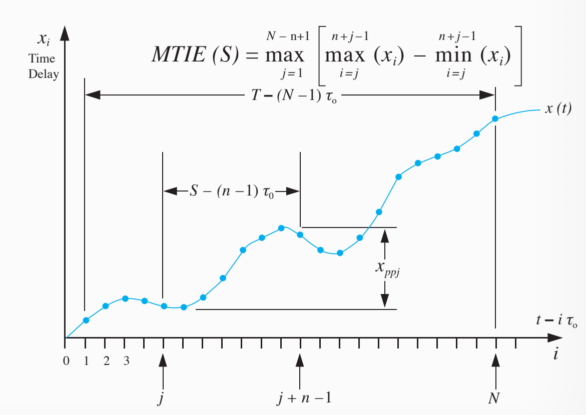
### TIE Measurement

- Measures the phase of a clock with respect to a reference clock
- Measures over long periods (hours or days)
- Uses raw data to calculate MTIE and TDEV



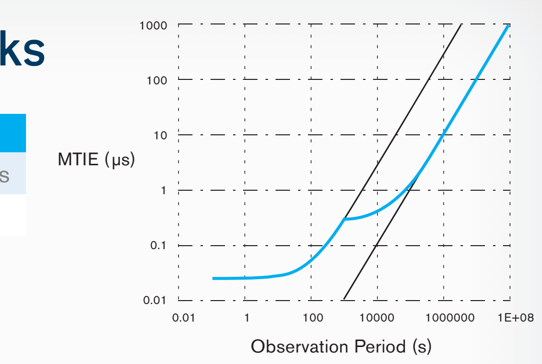

### MTIE Measurement

- Measures the maximum phase deviation over a measurement window
- Predicts clock frequency stability over time



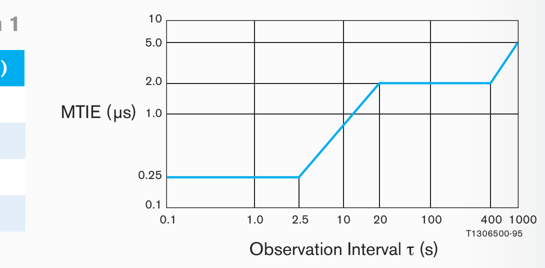

## MTIE Performance Masks

| MTIE |
|---|
| $(0.275 \times 10^{-3}\tau + 0.025)$ µs for $0.1\text{s} < \tau \le 1000$ s |
| $(10^{-5}\tau + 0.29)$ µs for $\tau > 1000$ s |



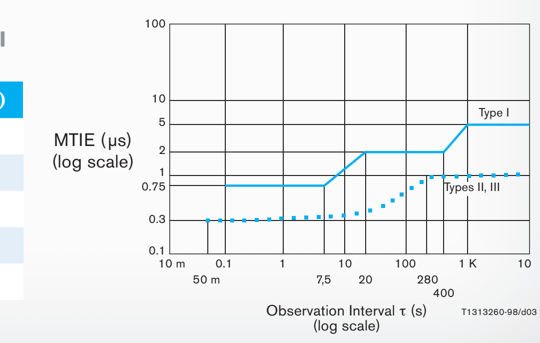

**G.813-Input Wander Tolerance (MTIE) for Option 1**

| MTIE Limit (µs) | Observation Interval τ (s) |
|---|---|
| 0.25 | $0.1 < \tau \le 2.5$ |
| $0.1\ \tau$ | $2.5 < \tau \le 20$ |
| 2 | $20 < \tau \le 400$ |
| $0.005\ \tau$ | $400 < \tau \le 1000$ |

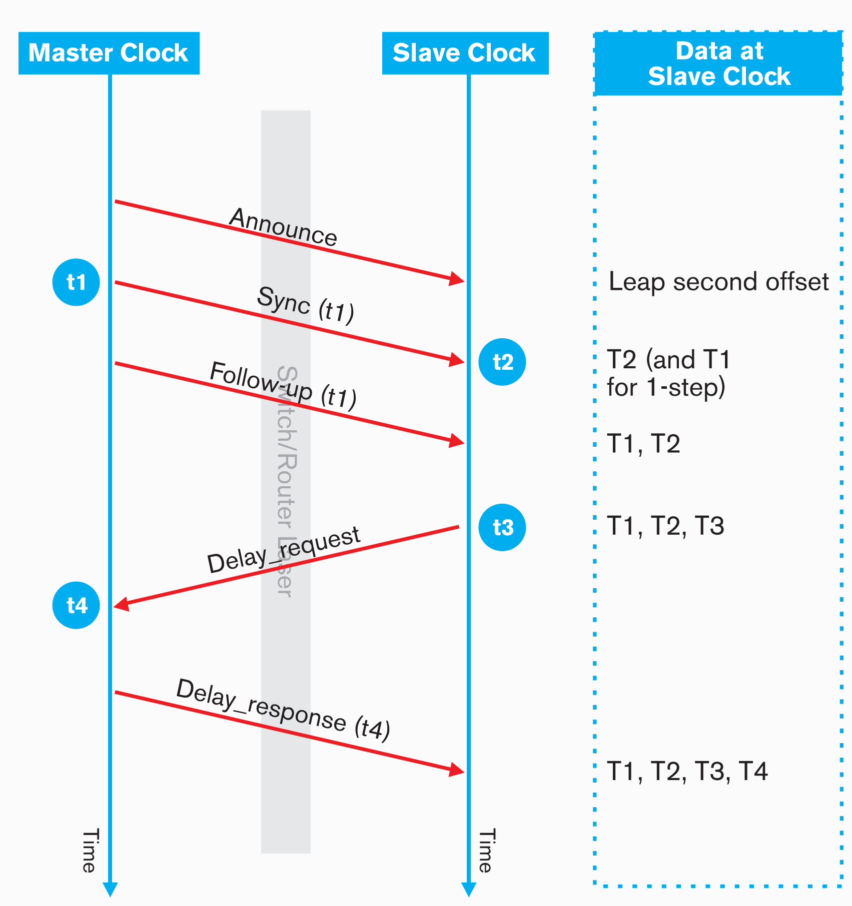



**G.812-Input Wander Tolerance (MTIE) for Type I Node Clock**

| MTIE Limit (µs) | Observation Interval τ (s) |
|---|---|
| 0.75 | $0.1 < \tau \le 7.5$ |
| $0.1\ \tau$ | $7.5 < \tau \le 20$ |
| 2 | $20 < \tau \le 400$ |
| $0.005\ \tau$ | $400 < \tau \le 1000$ |
| 5 | $1000 < \tau \le 10\ 000$ |




## 1588v2 General Flow State




The process is repeated up to 128 times per second.
Announce rate is lower than sync rate.

Round-Trip Delay
RTD = (T2 – T1) + (T4 – T3)

Offset (slave clock error and one-way path delay)
$\text{Offset}_{SYNC}$ = T2 - T1
$\text{Offset}_{DELAY\_REQ}$ = T4 - T3

Assuming path symmetry, therefore
One-Way Path Delay = RTD

Slave Clock Error = (T2 - T1) - RTD

**Notes**

1. One-way delay cannot be calculated exactly, but there is a bounded error.
2. The protocol transfers TAI (Atomic Time). UTC time is TAI + leap second offset from the announce message.

## PTP/IEEE 1588v2

PTP is a synchronization scheme that provides high clock accuracy in a packet network by continuously exchanging packets with appropriate timestamps.

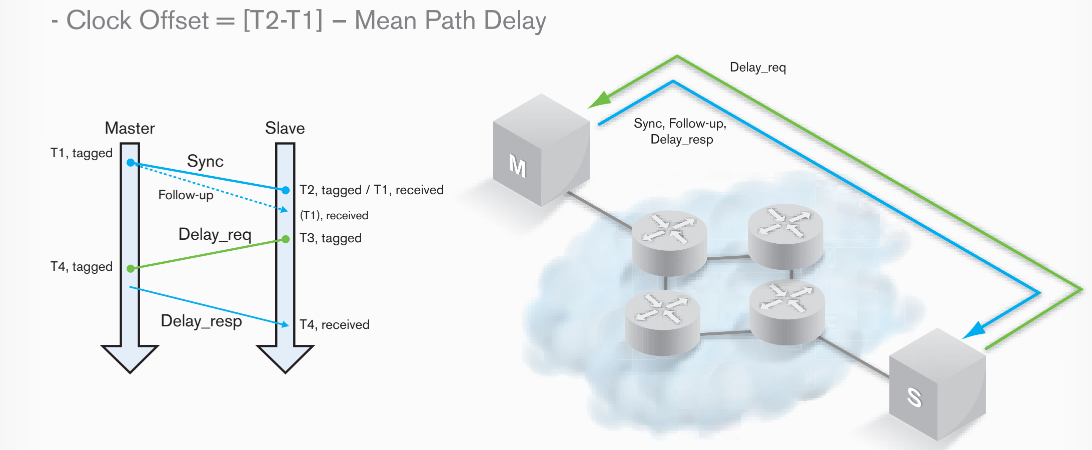
A grandmaster clock is a very precise clock source that generates timestamp announcements and responds to timestamp requests from boundary clocks and slave clocks.

Slave/client clocks are clocks that receive synchronization from the grandmaster clock.

## IEEE-1588v2 Architectures

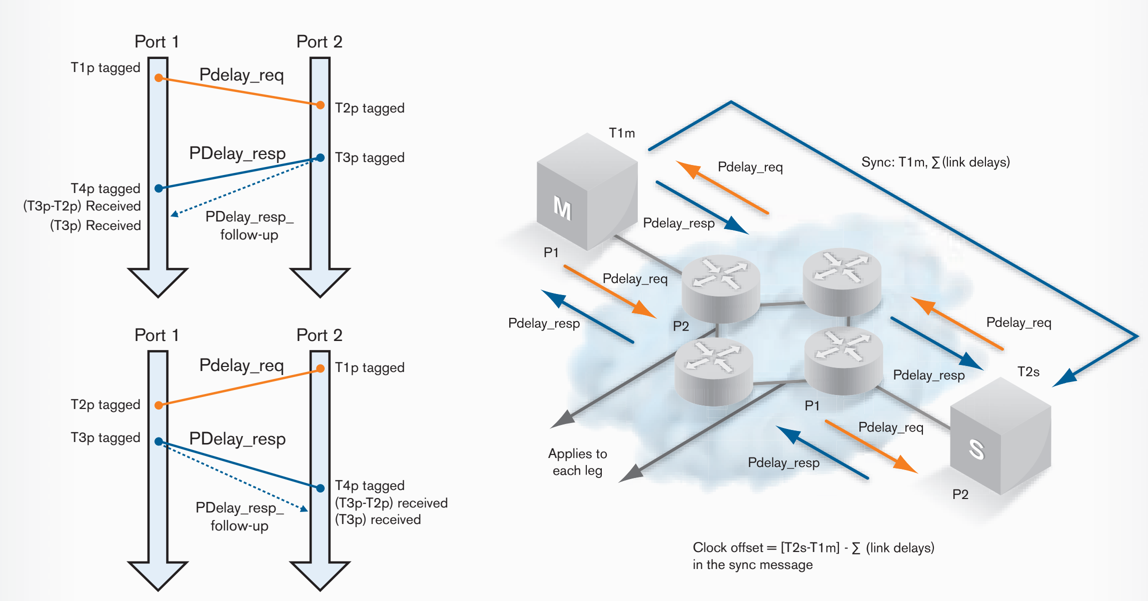
### Delay Request-Response Model

- The master and slave(s) exchange messages directly
- The slave is the only one that calculates the clock offset:
  - Mean Path Delay = [ [ T2-T1] + [ T4-T3] ] / 2
  - Clock Offset = [T2-T1] – Mean Path Delay




### Peer-to-Peer Model

- Each node in the network measures the port-to-port propagation time (i.e., the link delay between two communicating ports that support the peer delay mechanism)
- The sum of all path delays is added to the sync message




| Bits | | | | | | | | Number of Bytes | Offset |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | |
| transportSpecific | | | | messageType | | | | 1 | 0 |
| reserved | | | | versionPTP | | | | 1 | 1 |
| messageLength | | | | | | | | 2 | 2 |
| domainNumber | | | | | | | | 1 | 4 |
| reserved | | | | | | | | 1 | 5 |
| flagField | | | | | | | | 2 | 6 |
| correctionField | | | | | | | | 8 | 8 |
| reserved | | | | | | | | 4 | 16 |
| sourcePortIdentity | | | | | | | | 10 | 20 |
| sequenceID | | | | | | | | 2 | 30 |
| controlField | | | | | | | | 1 | 32 |
| logMessageInterval | | | | | | | | 1 | 33 |

## Synchronous Ethernet SSM Format (ITU-T G.8264/Y.1364)

**IEEE Assigned OUI and SPS**

| | |
|---|---|
| Organizational Unique Identifier | 0x0019A7 |
| Slow Protocol Subtype | 0x0A |

**QL TLV Format**

| | |
|---|---|
| 8 bits | Type: 0x01 |
| 16 bits | Length: 0x04 |
| 4 bits | 0 (unused) |
| 4 bits | SSM code |

**ESMC PDU Format**

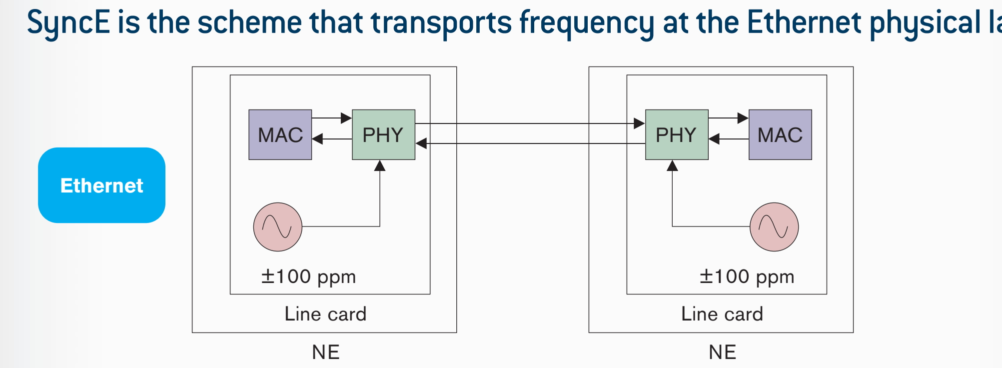
| Octet Number | Size | Field |
|---|---|---|
| 1-6 | 6 octets | Destination address = 01-80-C2-00-00-02 (hex) |
| 7-12 | 6 octets | Source address |
| 13-14 | 2 octets | Slow protocol Ethertype = 88-09 (hex) |
| 15 | 1 octet | Slow protocol subtype = 0A (hex) |
| 16-18 | 3 octets | ITU-OUI = 00-19-A7 (hex) |
| 19-20 | 2 octets | ITU subtype |
| 21 | 4 bits | Version |
| | 1 bit | Event flag |
| | 3 bits | Reserved |
| 22-24 | 3 octets | Reserved |
| 25-1532 | 36-1490 octets | Data and padding |
| Last 4 | 4 octets | FCS |

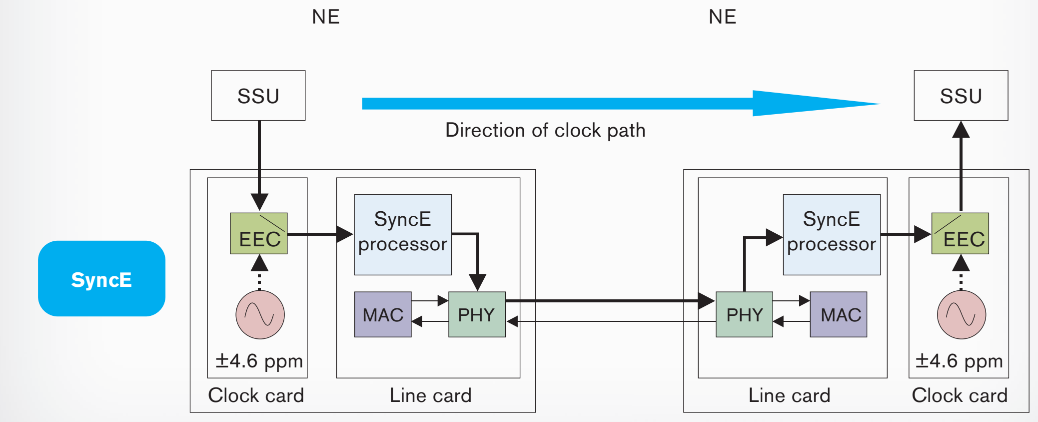
**SSM Message for SyncE**

| Clock | Message | SSM Code |
|---|---|---|
| EEC1 | QL-EEC1 | 1011 |
| EEC2 | QL-EEC2 | 1010 |

## Synchronous Ethernet (SyncE)

SyncE is the scheme that transports frequency at the Ethernet physical layer

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