Clock Device for Packet Based Network Synchronization

TN160107TD

Over view

With the universal deployment of Ethernet, ‘circuit switched networks’ have been shifting to new ‘packet switched networks’. Former voice telephony (PST: public switch telephone) is based on frequency synchronization. However, packet switched networks are inherently asynchronous; timing control technology is required to transfer voice, TDM (time division modulation) data through packed based network. Currently, there are two main solutions.

1) Synchronous Ethernet (SyncE: frequency synchronization type), 2) IEEE1588 (timing synchronization type).

Epson provides the oscillation devices that sustain the basic and indispensable technology for packed based network. High performance timing devices are especially important for lower PDV (packet delay variation) feature, and backup function during timing network outage. Thus Wander (MTIE, TDEV) and Holdover specifications are important specifications.

This application note explains Epson’s basic products deployment.

1. Timing Synchronization

Fig1 shows a typical mobile network. PRC (Primary Reference Clock) is the master clock of this system. For proper system operation, the timing information of PRC should be transmitted through the network to edge Macro-cell Base Station A and B, Small-cell Base Station A and B. Previous synchronization methods (SONET/SDH) can only transmit frequency information. However, packed based networks (Figure 1 EEC: Ethernet Equipment Clock) are inherently asynchronous. To synchronize through an asynchronous network, two solutions are proposed from ITU-T.

1) Synchronous Ethernet (SyncE). 2) IEEE1588. The next clause explains these two solutions.

Figure 1: A typical mobile network
2. Ethernet vs SyncE vs IEEE1588

SyncE transmits frequency (through PHY layer), IEEE1588 transmits time (through protocol layer).

(See Table 1, Figure 2, 3, 4)

<table>
<thead>
<tr>
<th>type</th>
<th>Sync/Async</th>
<th>layer</th>
<th>Oscillator (on node)</th>
<th>Main specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>Asynchronous</td>
<td>——</td>
<td>——</td>
<td>+/-100pp</td>
</tr>
<tr>
<td>SyncE</td>
<td>Synchronous</td>
<td>frequency</td>
<td>Physical</td>
<td>EEC compatible</td>
</tr>
<tr>
<td>IEEE1588</td>
<td>Synchronous</td>
<td>frequency</td>
<td>Protocol (PTP)</td>
<td>Stratum3 Compatible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stratum3E compatible</td>
</tr>
</tbody>
</table>

Table 1: Ethernet vs SyncE vs IEEE1588

Figure 2 Ethernet

Ethernet (Figure 2) does not transmit timing information. Asynchronous network.

Figure 3 Synchronous Ethernet (SyncE)

PRC frequency signal can be transmitted to lower (right side) nodes through Ethernet PHY which have EEC (Ethernet Equipment Clock) with CDR function (CRD: clock data recovery). All Nodes should be equipped with EEC devices. SyncE can transmit frequency only, not time. PRC and final destination Node have the same frequency. (Frequency Synchronized).

(EEC: Ethernet Equipment Clock. The standard (ITU-T G.8261 Option1,2) compatible clock.

Figure 4 IEEE1588
IEEE1588 (Figure 4) transmits frequency and time information from PRTC to target Node by protocol layer (basically PTP (Precision Timing Protocol). The target Node has the same time and frequency. This is timing synchronization. All Nodes may be equipped with normal Ethernet Clock. The final Node should be equipped with high stability oscillators (ex. TCXO, OCXO) to reduce PDV and provide redundant function (backup clock during timing signal interruption).

3. Standards for solutions

Worldwide standards (ex. ITU-T etc.) are published for synchronization solutions. (see Table 2)

<table>
<thead>
<tr>
<th>solution</th>
<th>Layer</th>
<th>Network Standard</th>
<th>Equipment, Clock Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SONET/SDH</td>
<td>PHY (L1)</td>
<td>frequency</td>
<td>ITU-T G.825</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SyncE</td>
<td>PHY (L1)</td>
<td>phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protocol (L2~3)</td>
<td>frequency</td>
</tr>
<tr>
<td>PEC (Frequency)</td>
<td>Protocol (L2~3)</td>
<td>frequency</td>
<td>ITU-T G.8261</td>
</tr>
<tr>
<td>PEC (Phase/Time)</td>
<td>Protocol (L2~3)</td>
<td>Time</td>
<td>ITU-T G.8271</td>
</tr>
</tbody>
</table>

Note
*1 IEEE1588 : PEC(Phase/Time)
*2 ITU-T has published standards.
*3 ITU-T has not finalized standards for PEC solutions.
From these standards, two main tiers of oscillator devices are used:

(Based on Telcordia Stratum)

<Telcordia GR-1244Core Stratum3 / G.812 Option 2 (SONET/SDH Equipment Clock) / G.8262 Option 2>
- Frequency Accuracy +/-4.6ppm (20 years)
- Frequency Stability +/-300ppb (1day)
- Frequency Drift +/-40ppb (1day constant temp.)
- MTIE, TDEV, Holdover refer to each standards.

<Telcordia GR-1244Core Stratum3E / G.812 Typ3>
- Frequency Accuracy +/-4.6ppm (20 years)
- Frequency Stability +/-10ppb (1day)
- Frequency Drift +/-1ppb (1day constant temp.)
- MTIE, TDEV, Holdover refer to each standards.

4. Epson product strategy

To meet these two levels of performance, Epson has several oscillator options:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Product</th>
<th>Products Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratum3</td>
<td>TCXO</td>
<td>TG-5500 series, TG5032 series</td>
</tr>
<tr>
<td>Stratum3E</td>
<td>OCXO</td>
<td>OG2525 series, OG2522series, OG1409 series</td>
</tr>
</tbody>
</table>

Epson will provide these products application notes consequently.