Configuring Synchronous Ethernet

The ME 3800X and ME 3600X switches support Synchronous Ethernet (SyncE), which is the PHY-layer frequency-synchronization solution for IEEE 802.3 links. It is an evolution of the conventional Ethernet and Ethernet + SDH and SONET-based synchronization. SyncE is used to synchronize and send clock information to remote sites on the network. Each network element along the synchronization path must support SyncE. SyncE provides only frequency synchronization, not related to time or space.

- Understanding SyncE, page 6-1
- Configuring SyncE, page 6-5
- Monitoring SyncE, page 6-11

Understanding SyncE

SyncE provides a method to synchronize the Ethernet network by having all Ethernet ports send data based on a reference clock. All devices supporting SyncE must send and receive data in cycles of fixed size and duration. The data size depends on the Ethernet speed. The rate of transmission is 8000 cycles per second. Each device must be able to support a system timing master, which is the synchronization source. A sync port is the port on which synchronization information is received. All SyncE frames coming from the sync port are the source of synchronization for all other ports on the device.

The switch 10 Gigabit Ethernet uplink ports or BITS interface support line clock recovery, sending and receiving clock information. Downlink ports do not perform clock recovery and can only send clock signals.

The switch supports TI (1544 kilobits/s) and E1 (2048 kb/s or 2048 KHz) clock timing synchronization.

- Reference Clocks, page 6-1
- SyncE Timing Using REP for Loop Prevention and Resiliency, page 6-2
- BITS Interface, page 6-5

Reference Clocks

A switch comes up in a free-run state, using the internal oscillator (Stratum 3) for synchronization. If there is a valid clock reference with a set priority, the switch locks to that reference. If there is no reliable clock source available, the switch remains in free-run mode. If the current clock becomes invalid, the switch goes into holdover mode and replays the saved clock from the last source. The switch SYNC LEDs show the status of the internal clock: locked (green), free run (off), or in a holdover state (amber).
The reference clock source can be:

- A Building Integrated Timing Supply (BITS) clock input
- A PHY-recovered clock from uplink ports. The ME 3800X and 3600X switch supports a PHY-recovered clock only from the small form-factor pluggable (SFP+) uplink ports with 10 Gigabit SFP+ or 1000BASE-X fiber SFP modules.

All uplink and downlink ports transmit data on the same reference clock.

The switch monitors each input clock for frequency accuracy and activity. An input clock with a frequency out-of-band alarm or an activity alarm is invalid. Invalid clocks are not selected as the reference clock.

During normal operation, the reference clock is selected based on an algorithm that uses the priority rankings that you assign to the input clocks by using the `network-clock-select priority priority` global configuration command. Priority 1 is the highest, and priority 15 is the lowest. If you try to assign the same priority to more than one clock, an error message appears. Unused input clocks are given a priority value of 0, which disables the clocks and makes them unavailable for selection. The clock selection is based on signal failure, priority, and manual configuration. If you have not manually configured a reference clock, the algorithm selects the clock with the highest priority that does not experience signal failure.

With this configuration, pure priority-based mode, an intermittent failure or changes in the network topology can cause timing loops or a loss of connectivity with the clock reference. The Ethernet Synchronous Messaging Channel (ESMC) with source-specific multicast (SSM) provides a way to implement quality in synchronous networks, but this feature is not supported on the ME 3800X and 3600X switches. We recommend configuring the SyncE network as a Resilient Ethernet Protocol (REP) segment for resiliency and to avoid timing loops when there are any network failures within the segment. See “SyncE Timing Using REP for Loop Prevention and Resiliency” section on page 6-2

Reference clocks operate in revertive or nonrevertive mode, configured by using the `network-clock-select mode` global configuration command.

- In revertive mode, if an input clock with a higher priority than the selected reference becomes available, the higher priority reference is immediately selected.
- In nonrevertive mode, if an input clock with a higher priority becomes available, the higher-priority clock is selected only when the current clock becomes invalid or unavailable.

You can use the `set network-clocks` privileged EXEC command to configure the input reference to be either forced or automatically selected by the selection algorithm based on the highest priority valid input clock. In revertive mode, the forced clock automatically becomes the selected reference. In nonrevertive mode, the forced clock becomes the selected reference only when the existing reference is invalidated or unavailable.

**SyncE Timing Using REP for Loop Prevention and Resiliency**

In pure priority-based mode, there is a risk of timing loops if the network topology changes. You can use a REP workaround to avoid timing loops and to ensure timing resiliency. REP is a Cisco protocol used to control network loops, to respond to link failures, and to improve convergence time. See Chapter 16, “Configuring Resilient Ethernet Protocol.” REP controls a group of ports connected to each other in a segment to ensure that the segment does not create any bridging loops and to respond to link failures within the segment.
A REP segment is a chain of ports connected to each other and configured with a segment identifier. Each segment consists of standard (non-edge) ports and two user-configured edge ports. A switch can have no more than two ports in the same REP segment and each segment port can have only one external neighbor. REP is supported only on Layer 2 trunk interfaces.

You can use REP in the SyncE network with a REP no-edge segment or with REP VLAN load balancing. You cannot configure SyncE as a REP segment and configure a BITS interface at the same time.

SyncE uses REP only for failure detection, and not for timing topology discovery or timing loop prevention. These SyncE features are achieved through correct configuration of port priorities. Timing loops can occur if priority is not correctly configured.

Configuring REP allows the segment to automatically respond to a failure in the ring and avoid timing loops by changing the direction of the reference clock path. Figure 6-1 shows how you can configure a REP segment in a SyncE network. The 10 Gigabit ports are used to connect the switches.

After you have configured switch network clock priority and configured the REP network, enter the `ql-enabled rep-segment segment-id` command to identify the REP segment to with SyncE.

Figure 6-1  SyncE REP Segment

Figure 6-2 shows a failure in the timing network, a broken link in the REP segment between Switch 4 and Router 1.
Understanding SyncE

Figure 6-2  
**Broken Network Link**

Figure 6-3  shows how the REP segment handles the broken link to avoid timing loops in the SyncE network.

**Figure 6-3  SyncE REP Segment**

When you configure the SyncE REP workaround, you can configure these SyncE features:

- **Hold-off timeout**—If a clock source goes down, the switch holds the fail signal for a specific time period before removing the source and restarting the synchronization process. Configure the hold-off timeout by entering the `network-clock-select hold-off timeout` global configuration command.

- **Wait-to-restore timeout**—If a failed SyncE source comes up, the switch waits for a specific time period of time before considering the source as available in the selection process. The default time is 300 seconds. Configure wait-to-restore timeout by entering the `network-clock-select wait-to-restore` global configuration command.
• Holdover time or hold timeout—You can specify how long the switch replays the saved clock from the last source if there is the clock source becomes unavailable before it moves from holdover state to free run. Configure holdover time by using the `network-clock-select hold-timeout` global configuration command. You can configure the time as infinite or as a range from 0 to 86,400 seconds.

When you do not configure REP with clock selection, the time is always infinite; the saved clock replays forever. In pure priority-based mode, when the switch goes to holdover, it stays in this state forever and does not transition to free-run state (even after the holdover value is exceeded and the clock accuracy becomes like free run).

**BITS Interface**

The ME 3800X and ME 3600X switch supports a BITS interface through an RJ-45 connector. The connection can be used for sending and receiving T1 and E1 timing signals.

You can configure all Ethernet ports to send data referenced to the BITS recovered clock. The BITS signal is used as long as it does not have these faults:

- loss of signal
- out of frame
- alarm-indication signal
- remote alarm indication

The switch supports BITS IN and BITS OUT, and recovers and sends BITS timing, T1, E1, or 2.048 KHz. The switch does not support T1 or E1 data transmission. You can configure the BITS interface input and output, including line coding and line buildout (output). You can also shut down the BITS controller.

The switch supports these BITS configurations:

• E1 Mode:
  - 2048 KHz
  - Framing mode: FAS, MFAS, FASCRC4, MFASCRC4 with line coding: AMI, HDB3

• T1 Mode:
  - Framing mode: D4 and ESF
  - Line coding: AMI, B8ZS
  - Line buildout (output): 0 to 133 feet, 133 to 266 feet, 266 to 399 feet, 399 to 533 feet, or 533 to 655 feet

**Configuring SyncE**

SyncE limitations on copper ports:

• To receive clock data from an ME 3600X-TS 1 Gigabit Ethernet copper SFP interface, the link partner must not be the 802.3 master port when 802.3 Clause 28 autonegotiation completes.

• On ME3600X-FS or ME3800X switches, SyncE is not supported on 1 Gigabit Ethernet copper SFPs for the first release.
Default SyncE Configuration

Synchronous Ethernet is not configured on 10 Gigabit Ethernet interfaces. 1 Gigabit Ethernet interfaces transmit SyncE with no configuration required. No configuration is needed to send clock timing in uplink or downlink interfaces.

Clock recovery is not configured on an uplink interface, which could be a 10 GigabitEthernet port or a 1 Gigabit- Ethernet fiber SFP.

Configuring the Network Clock Selection

Beginning in privileged EXEC mode, follow these steps to configure the SyncE network clock.

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>configure terminal</td>
</tr>
<tr>
<td>Step 2</td>
<td>network-clock-select priority {BITS</td>
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<tr>
<td>Step 3</td>
<td>network-clock-select output priority SYMCE port</td>
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</tbody>
</table>
**Command** | **Purpose**
--- | ---
Step 4 network-clock-select mode {nonrevert | revert} | (Optional) Configure the reference switching mode to determine the action to be taken if an input clock with a higher priority than the selected reference becomes valid.
  - **nonrevert**—The new clock does not immediately become valid but is selected only if the current reference becomes invalid.
  - **revert**—The higher priority reference is immediately selected as the reference clock. This is the default.
Step 5 end | Return to privileged EXEC mode.
Step 6 show network-clocks | Verify the configuration.
Step 7 copy running-config startup config | (Optional) Save your entries in the switch startup configuration file.

Enter the **no network-clock-select priority** or **network-clock-select output** to remove the selected priority. Enter the **no network-clock-select mode revert** or the **no network-clock-select mode nonrevert** to select the other mode.

This example configures the BITS clock with a priority of 2 and the SyncE input port as 10 Gigabit Ethernet port 0/1 with the switching mode as nonrevertive.

`Switch (config)# network-clock-select priority 2 BITS`  
`Switch (config)# network-clock-select output 2 SYNCE 0`  
`Switch (config)# network-clock-select mode nonrevert`  
`Switch (config)# end`

**Configuring the BITS Interface**

Beginning in privileged EXEC mode, follow these steps to configure the BITS interface. The Ethernet Equipment Clock (EEC) mode of operation is based on the area of deployment.

---

**Command** | **Purpose**
--- | ---
Step 1 configure terminal | Enter global configuration mode.
Step 2 network-clock-select option {option1 | option2} | Configure the EEC option:
  - **option1**—Select E1 as the input clock rate.
  - **option2**—Select T1 as the input clock rate
### Step 3

**controller BITS input applique E1**

```
2048KHz | framing option linecode {ami | hdb3}
```

or

```
controller BITS input applique T1 framing {d4 | esf} linecode {ami | b8zs}
```

(Optional) Configure the controller BITS input framing and coding options.

For E1 input:
- `2048KHz`—Select 2048 KHz input.
- `framing option`—Select one of these options:
  - `fas_crc4`—FASCRC4
  - `fas_nocrc`—FAS
  - `mfas_crc4`—MFASCRC4
  - `mfas_nocr`—MFAS

For T1 input:
- `d4 linecode`—D4
- `esf linecode`—Extended superframe
- `linecode ami`—AMI encoding
- `linecode b8zs`—B8ZS encoding

### Step 4

**controller BITS output applique E1**

```
2048KHz | framing options | linecode {ami | hdb3}
```

or

```
controller BITS output applique T1 framing {d4 | esf} linecode {ami | b8zs} line-build-out length
```

(Optional) Configure the controller BITS output framing and coding options.

For E1 output:
- `2048KHz`—Select 2048 KHz input.
- `framing`—Select one of these options:
  - `fas_crc4`—FASCRC4
  - `fas_nocrc`—FAS
  - `mfas_crc4`—MFASCRC4
  - `mfas_nocr`—MFAS

For T1 framing output:
- `d4 linecode`—D4
- `esf linecode`—Extended superframe
- `linecode ami`—AMI encoding
- `linecode b8zs`—B8ZS encoding
- `line-build-out length`—Select a line length:
  - 0-133ft
  - 133-266ft
  - 266-399ft
  - 399-533ft
  - 533-655ft

### Step 5

**controller BITS shutdown**

Shut down the BITS controller.

### Step 6

**end**

Return to privileged EXEC mode.
Enter the `no network-clock-select mode option option 1` or the `no network-clock-select mode option option 2` to select the other option. mode with the default E1 or T1 values.

Use the `no` form of each command to remove the configuration or return to the default.

This example configures EEC as T1 with ESF framing, B8ZS line coding, and 1 to 133 foot line buildout.

```
Switch (config)# network-clock-select option option2
Switch (config)# controller BITS input applique T1 framing esf linecode b8zs
Switch (config)# controller BITS output applique T1 framing esf linecode b8zs
Switch (config)# line-build0-out 0-133ft
Switch (config)# end
Switch# show controllers BITS
Applique type is T1
Line Coding is B8ZS(Rx), B8ZS(Tx)
Framing is ESF(Rx), ESF(Tx)
Line Build Out is 0-133ft
No alarms detected.
```

### Selecting the Network Clock

You can force selection of a particular network clock or select automatic clock selection where the switch uses the selection algorithm based on the priority and the validity of the input.

Beginning in privileged EXEC mode, use this step to set the SyncE network clock.

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>Step 8</strong></td>
</tr>
<tr>
<td>show controller BITS</td>
<td>copy running-config startup config</td>
</tr>
<tr>
<td>Verify the configuration.</td>
<td>(Optional) Save your entries in the switch startup configuration file.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td><strong>Step 9</strong></td>
<td><strong>Step 10</strong></td>
</tr>
<tr>
<td>set network-clocks {automatic</td>
<td>force-reselect</td>
</tr>
<tr>
<td>Select one of these options:</td>
<td>Verify the configuration.</td>
</tr>
<tr>
<td>• <strong>automatic</strong>—Use the clock selection algorithm to select the clock.</td>
<td></td>
</tr>
<tr>
<td>• <strong>force-reselect</strong>—Force the system to select the valid input clock with the highest priority and to always keep this clock as the reference clock.</td>
<td></td>
</tr>
<tr>
<td>• <strong>next-select</strong>—Force selection of the next valid input clock with the highest priority.</td>
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<tr>
<td>If the switch is in nonrevertive mode, the clock input does not change unless the current clock becomes invalid.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td><strong>Step 11</strong></td>
<td><strong>Step 12</strong></td>
</tr>
<tr>
<td>copy running-config startup config</td>
<td>show running-config</td>
</tr>
<tr>
<td>(Optional) Save your entries in the switch startup configuration file.</td>
<td>Verify the configuration.</td>
</tr>
</tbody>
</table>
Configuring REP for the SyncE Network

Beginning in privileged EXEC mode, use this procedure to configure a REP segment to avoid timing loops when a failure occurs. In SyncE ring topologies, we recommend that you configure REP.

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>configure terminal</td>
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<tr>
<td><strong>Step 2</strong></td>
<td>network-clock-select priority SYNCE port number</td>
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<tr>
<td><strong>Step 3</strong></td>
<td>rep administration vlan vlan-id</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>network-clock-select mode revert</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>ql-enabled rep-segment segment-id</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td>network-clock-select hold-off-timeout value</td>
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<tr>
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<tr>
<td><strong>Step 7</strong></td>
<td>network-clock-select hold-timeout {value</td>
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<tr>
<td><strong>Step 8</strong></td>
<td>network-clock-select wait-to-restore value</td>
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</tbody>
</table>
Use the no versions of the commands to disable the REP workaround segment selection or return to the default settings.

This example configures the REP workaround and sets the clock input ports:

```
Switch (config)# rep administrative vlan 2
Switch (config)# network-clock-select output 2 SYNCE 0
Switch (config)# interface tengigabitethernet 0/1
Switch (config-if)# switchport mode trunk
Switch (config-if)# rep segment 2
Switch (config-if)# exit
Switch (config)# ql-enabled rep-segment 3
Switch (config)# network-clock-select 1 SYNCE 0
Switch (config)# network-clock-select 2 SYNCE 1
Switch (config)# interface tengigabitethernet 0/2
Switch (config-if)# switchport mode trunk
Switch (config-if)# rep segment 2
Switch (config-if)# exit
Switch (config)# network-clock-select mode revert
Switch (config)# network-clock-select wait-to-restore-timeout 300
Switch (config)# network-clock-select hold-off-timeout 300
Switch (config)# end
```

### Monitoring SyncE

Use these privileged EXEC commands to view SyncE configuration on a switch:

- **show controller BITS**

  ```
  Switch# show controller BITS
  
  Appliance type is T1
  Line Coding is B8ZS(Rx), B8ZS(Tx)
  Framing is ESF(Rx), ESF(Tx)
  Line Build Out is 0-133ft
  No alarms detected.
  ```

- **show network-clocks**

  ```
  Switch# show network-clocks
  
  Network Clock Configuration
  Input Clock BITS: valid
  Input Clock SYNNCE Te0/1: valid
  Input Clock SYNNCE Te0/2: valid
  System Clock Lock Status (T0DPLL): Locked
  Output Clock Generated from T4 DPLL
  T4 DPLL Lock Status: Locked
  System Clock Selected Ref: Te0/2
  T4 DPLL Selected Ref: Te0/1
  System Clock (T0 DPLL) Info:
  Priority Source Type
  ---------------------------------------------------------------
  01  Te0/2  SYNNCE
  ```

### Command Purpose

<table>
<thead>
<tr>
<th>Step</th>
<th>Command</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td>9</td>
<td>show network-clocks</td>
<td>Verify the configuration.</td>
</tr>
<tr>
<td>10</td>
<td>copy running-config startup config</td>
<td>(Optional) Save your entries in the switch startup configuration file.</td>
</tr>
</tbody>
</table>
T4 DPLL Clock Info:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Source</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Te0/1</td>
<td>SYNCE</td>
</tr>
</tbody>
</table>

System Clock Mode : Non Revertive
EEC Option Configured : Option 2
System Clock State is Automatic

hold-timeout : infinite
ESMC/SSM workaround using REP not configured

Measured offset freq for input BITS is +0.0ppm (3.8 ppm resolution)
Measured offset freq for input Te0/1 is +0.0ppm (3.8 ppm resolution)
Measured offset freq for input Te0/2 is +0.0ppm (3.8 ppm resolution)
Measured offset freq for current path (T4 DPLL) is +0.0ppm