Appendix SY

Synchronization in SDH Equipments

Synchronization Sources

On a SDH equipment the following clock sources can be managed:

- *External timing sources*

  The system can be supplied with different external synchronization signals. These signals can be:

  - *2048kbit/s (HDB3);*
  - *2048kHz.*

- *Tributary and line sources*

  For each tributary unit a port can be selected and for each line unit the received signal can be selected, to be used as external timing reference.

An internal oscillator is also available with the following two operative states:

- *Free–Running*

  An internal clock signal is made available and it can be selected as MASTER CLOCK for the whole equipment with the stability specified by ITU–T recommendation G.813.

- *Holdover*

  The in–use source frequency is sampled and its average value is stored in a memory. If the selected source becomes unavailable, the system will synchronize its own oscillator using the stored average value.

Selection of Synchronization Sources

When the equipment has different synchronization sources, it is possible to select another source in case of failure of the active one.

The method for selecting the different sources can be based on either a priority table or a quality algorithm (SSM algorithm).

Normally the internal master clock (SEC – Synchronization Equipment Clock) is locked on one of the possible synchronization sources. When this source fails, the following actions take place:

- *automatic selection of a new synchronization source (if available) according to a priority table or SSM algorithm;*
- *SEC hold–over switch (if no synchronization source is available);*
- *'lost clock restoration' through revertive / not revertive method (only when the priority table is used);*
- *'stand–by clock management';*

Restoration means the possibility of re–inserting in the priority table, as valid synchronization sources, clock references that had been lost and that become available again.

Reversibility allows the automatic selection, as an active synchronization source, of a lost clock signal if this has the required quality characteristics.

Use of the priority table or the SSM algorithm method is selected by the operator via the local controller or NMC.

Priority Table

The selection of the synchronization source is made according with the priority table defined by the operator, using the LC or NMC. This table includes all the possible synchronization sources and associates to each of them a priority value.

The system will use, by default, the highest priority source; if this source fails, the system will automatically select the next available in the list.

Both revertive and not revertive operation can be used to restore the failed source.

If the revertive mode is set, the equipment will use the last synchronization source until a higher priority one is recovered or a failure happens on the current source. In the latter event, if a higher priority source is not yet available, the system will try to perform a change–over to the next one. In the worst case (no sources available) the oscillator enters the hold–over mode.
If, in the meantime, a higher priority source becomes available the system will select it for the current synchronization source.

The not revertive mode works in the same way as the revertive one. The only difference concerns the available sources. Using this mode the oscillator will not automatically revert to a higher priority source as soon as it becomes available but will be locked to the in–use source.

However if the equipment is in holdover and a source becomes available, the oscillator is automatically locked on the new entry.

Quality Table (Algorithm based on SSM)

The selection of the synchronization source is made according to a 'maximum quality source available' criterion.
STM–N signals carry both reference timing information and an indication of the quality level of the timing source from which they are derived. The quality level is written in bits 5 to 8 of S1 byte.

For other synchronization sources (tributary ports recovered clock and 2048kHz or 2048kbit/s external inputs) if no intrinsic quality information is present any quality, complying with SSM values, can be set by the local controller or the NMC.

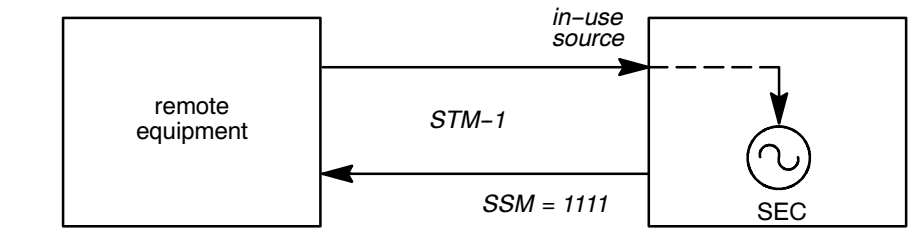
The quality levels are defined in ITU–T Recommendation G.707.

Quality levels of each valid synchronization source are represented as a table. In addition to the priority value, the quality level, either read on the incoming signal or set by the operator (using LC or NMC), is associated to every valid synchronization source in each entry of the table.

When an STM–N interface is selected as the current synchronization source, the SSM 'Don't use for synch.' (bit 5 to 8 of byte S1 set as 1111) is transmitted back in the STM–N signal to the remote equipment (see Fig. SY–1a).

When the SEC is in hold–over mode the value transmitted on the STM–N output signals is '1011' (G.813 quality). When the SEC is in free–running mode this value may be set either to '1111' (don't use for synch.) or to '1011' (G.813 quality).

In order to avoid synchronization loops in the network two STM–N interfaces can also be associated in the "S1 inhibition" table of a network element.
As soon as a STM–N interface is selected as a current synchronization source the transmitted S1 on the other interface will be forced to 'Don't use for synch.'(see Fig. SY–1b).



SSM = Quality Level of the in–use synchronization source
If the in–use source is a STM–n stream, on the corrispondent Tx side will be transmitted the value 'don't use for synch' (1111)

Fig.SY–1a

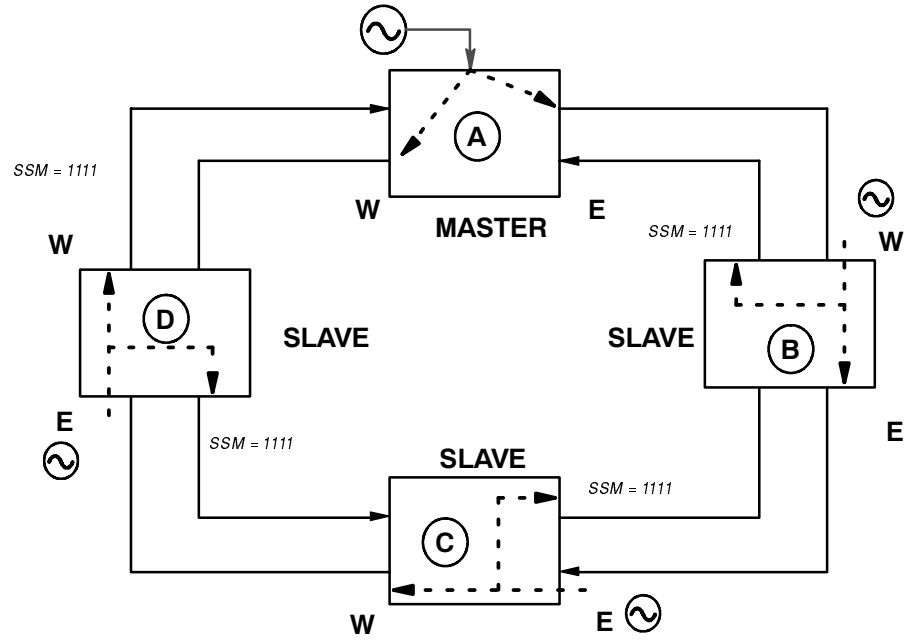


Fig.SY–1b

Fig. SY–1 *Timing Marker output management*

A 'minimum accepted quality level' can be set for both internal clock and the synchronization output. In the last case the synchronization output is squelched when no better or equal synchronization sources are available.

The selection algorithm based on SSM can be disabled so that the selection is dependant only on the priority list.

Timing configurations

Different timing configurations are available, depending on the equipment configuration.

External Timing (Fig. SY–2a)

The equipment times all outgoing signals to an external timing source.

Tributary Timing (Fig. SY–2b)

The equipment is capable of deriving timing from a Tributary Port.

Line Timing (Fig. SY–2c)

The equipment times all outgoing signals to the timing signal extracted from a line.

Internal Timing (Fig. SY–2d)

The equipment is also able to supply an internal clock source for providing synchronization. This is termed ”Free–running” mode.

Through Timing (Fig. SY–2e)

The equipment passes line timing through the multiplexer, west to east and/or east to west. The clock recovered from one side is used to time the outgoing signal on the other side. This type of timing architecture is used with regenerator configuration only.

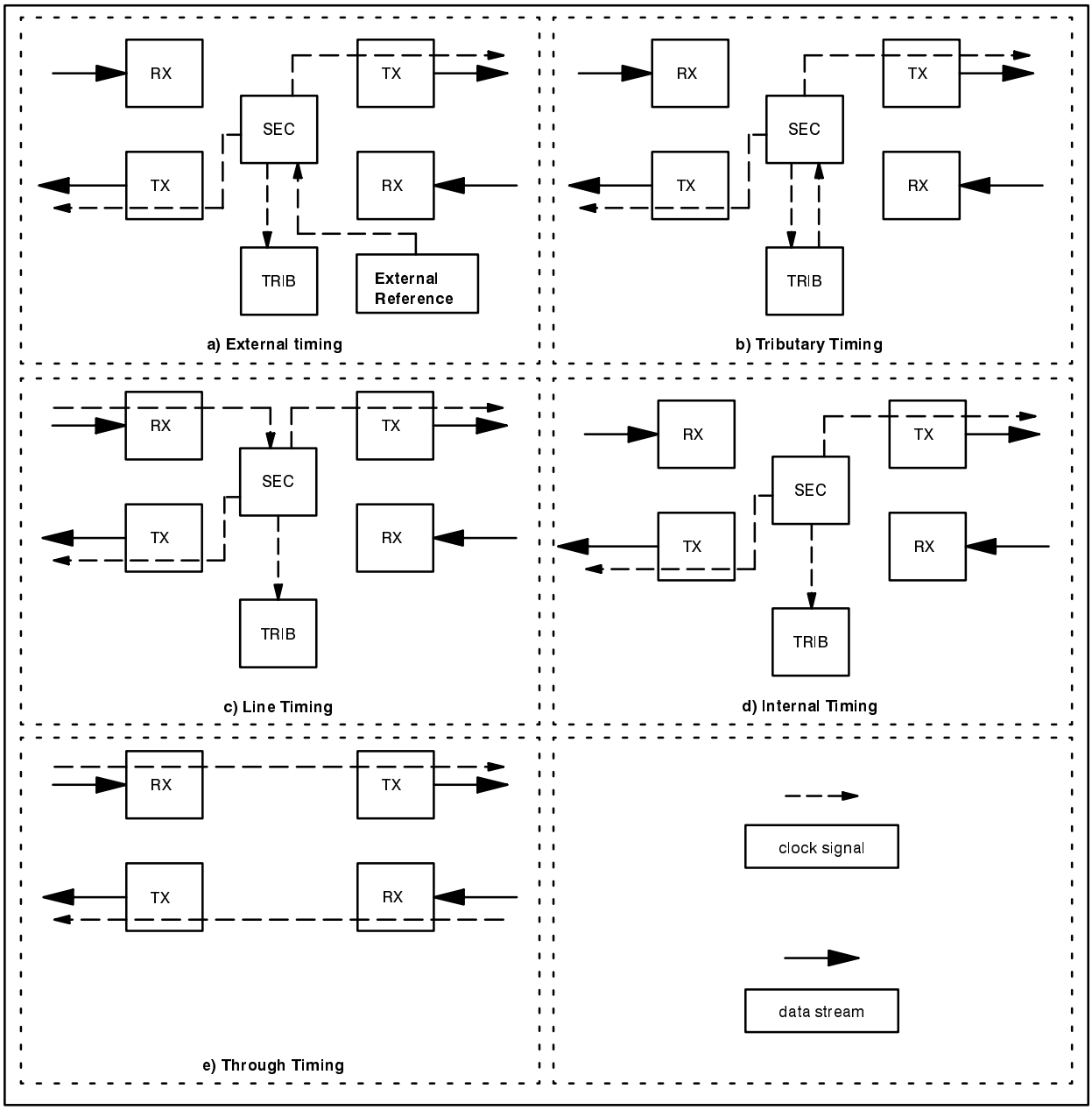
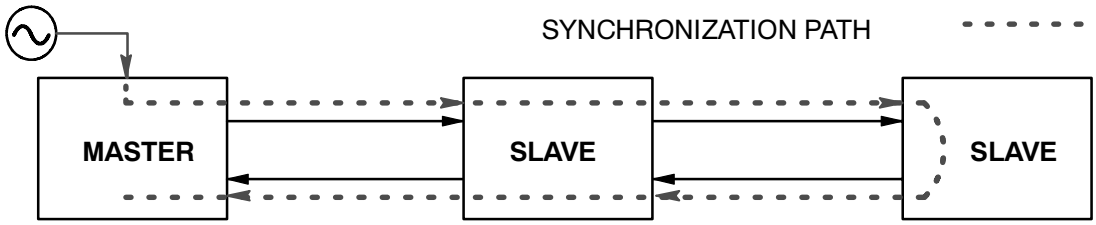


Fig. SY-2 *Timing options*

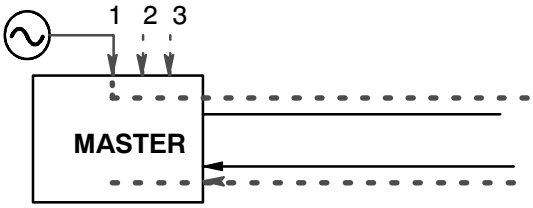
Network Synchronization Example

The goal for the timing of an SDH Network is to create a synchronization path in order to use the same clock reference for all the Network Elements (NE).
To reach this target one NE must be defined as MASTER for the synchronization while all the others NEs are SLAVE equipments.



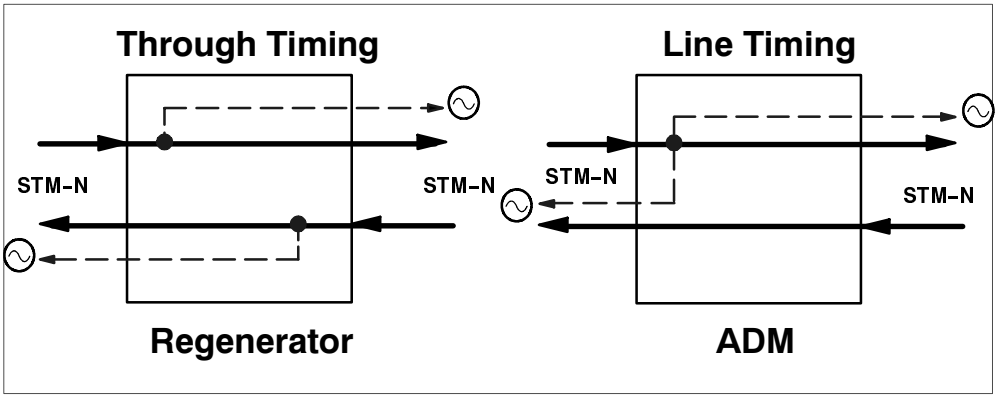
MASTER Equipment

The Master equipment is the one used to synchronize the whole network.
The MASTER is also normally synchronised by an external reference (clock signal or tributary input) that can be protected for greater availability.



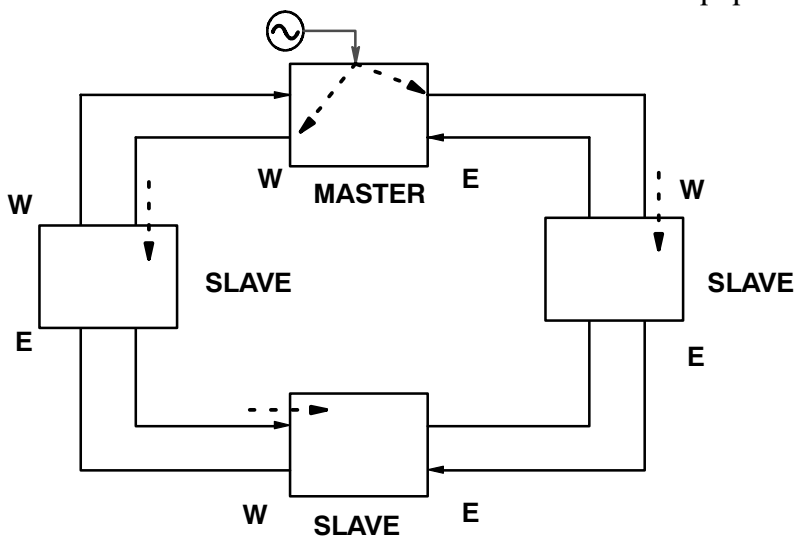
SLAVE Equipment

The Slave equipment extracts the synchronization signal from a received STM–N line interface and uses this clock reference to time its internal circuits and the signal transmitted on its line interfaces.
A Slave equipment can be synchronised in *line timing* or, if it is configured as a regenerator, in *through timing* mode.



Ring Synchronization Example

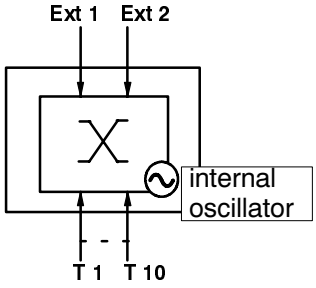
In the following the synchronization of a ring network is analyzed, paying attention to the different versions of master and slave equipments.



MASTER Equipment Synchronization

To synchronize a master equipment:

1. Use as synchronization sources only External References EXT1, EXT2, Tn or the internal oscillator (free–running mode).

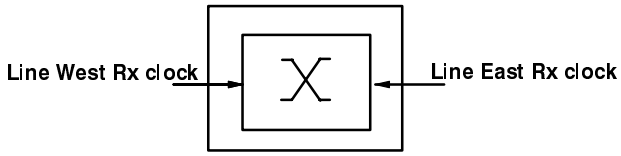


2. All the synchronization destinations (System, Line West Tx clock, Line East Tx clock) are to be synchronized using the same priority table (the one defined for the system).

SLAVE Equipment Synchronization

To synchronize a slave equipment:

1. Use as synchronization sources only clock incoming from the line interfaces (Line West Rx clock and Line East Rx clock)



2. Transmitted signals on Line West and Line East are to be synchronized with line timing mode.

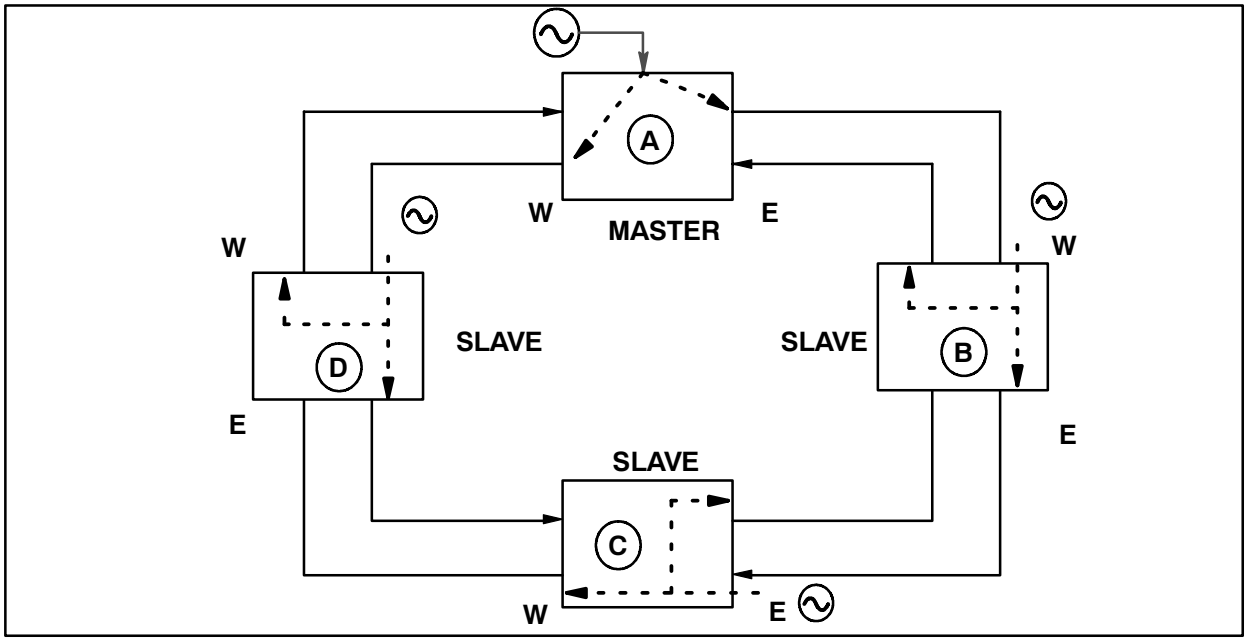


Fig. SY–3 *Normal Operation (line timing)*

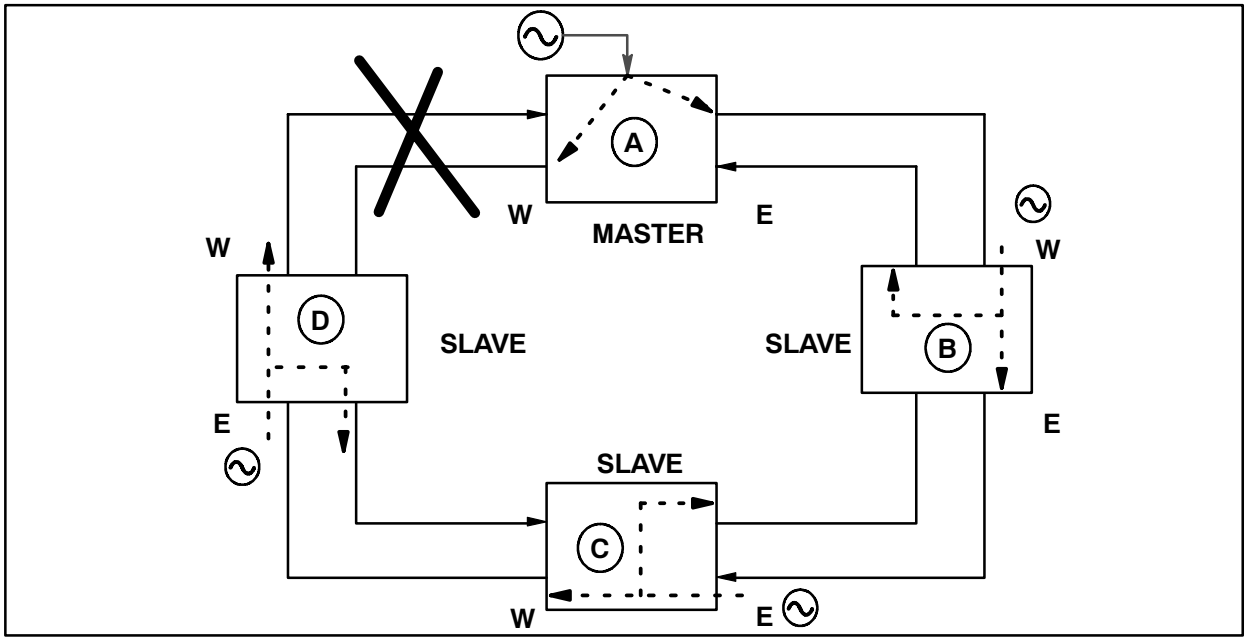


Fig. SY–4 *Synchronization Protection Switch in Equipment D*

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