



HPX-1600 USER GUIDE

Chapter 3-2: Node and network Clocks

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1. INTRODUCTION

Haliplex offer a wide range of voice and data multiplexers that can be used to create a network of multiplexers over a wide area, connected by data links transmitted over fibre optic, radio or copper circuits. The basic data unit used in these networks is a DS0 or 64Kbps, used to carry a single digitised voice signal or as part of a data signal. Multiple DS0 are combined into PCM data streams for transmission, 32xDS0 for E1 or 24xDS0 for T1. Transmission between network nodes is always in multiples of E1 or T1 signals. The two important timing issues to resolve are whether interfaces need to be locked with respect to a “system” clock, and whether framing is important.

In general, if T1/E1 data is to be transported without the need to access the payload at a DS0 granularity, then fully independent “ASYNC” clocking can be used for such tributaries. In this case, both the clock and framing information does not need to be known by the rest of the system and clock and payload frame are passed transparently in both directions. This is possible in the HPX-1600-EM, and HPX-1600-SS products. In fact this is the only option for the HPX-100, which does not have DACS capability.

Conversely, if cross-connection or grooming of the T1/E1 circuit is required at an n x DS0 granularity, then all data to/from the DACS must be timed back to a common clock source such that DS0 interchange can occur without slip. This is always the case for HPX-1600-IA.

- If DS0 grooming is required then all data to be groomed must have the timing referenced from a single source. The DACS timing will also use this source.
- Data contained in E1/T1 streams and required to be accessed at the DS0 level must be framed. This framing delineates the boundaries between adjacent DS0 channels in the payload.

2. TRIBUTARY CIRCUITS

Haliplex multiplexers support tributary circuits with a wide range of interfaces including, Ethernet, V.35/V.24/X.21, E1, T1 and voice systems. All tributary interfaces are internally converted to E1/T1 data streams, which are transmitted through the Haliplex node and the network either as synchronous or asynchronous tributaries.

2.1. SYNCHRONOUS TRIBUTARIES

Synchronous tributaries use a common network clock and are buffered by the E1/T1 interface to ensure correct frame alignment before connecting to a digital cross-connect switch or a synchronous trunk.

The following Haliplex multiplexers operate only with synchronous tributaries;

- HPX-200-IA
- HPX-200-OM
- HPX-300-IA
- HPX-300-OM
- HPX-1600-IA

The HPX-300-SS can be configured with a mixture of synchronous and asynchronous tributaries. Any circuits connected to the DACS operate in a synchronous mode. All other tributaries directly connected to the SDH trunk operate asynchronously.

2.2. ASYNCHRONOUS TRIBUTARIES

Asynchronous tributaries use independent clocks and are carried across the Haliplex network without being synchronised to node timing or framing.

The following Haliplex multiplexers operate with asynchronous tributaries;

- HPX-100
- HPX-300-EM
- HPX-300-SS
- HPX-1600-SS

The HPX-1600-SS can be configured with a mixture of synchronous and asynchronous tributaries. Any circuits connected to the DACS operate in a synchronous mode. All other tributaries directly connected to the SDH trunk operate asynchronously.

3. NETWORK TRUNK CIRCUITS

3.1. SYNCHRONOUS E1/T1 TRUNKS

Multiple E1/T1 trunk circuits can be connected in parallel between network nodes. One of these E1/T1 trunks is configured to synchronise the two connected network nodes and all E1/T1 circuits are clock and frame synchronised before transmission, this enables all the parallel E1/T1 circuits to be received using a common synchronous node clock. Multiple E1/T1 trunk circuits may also be combined in a composite, synchronous fibre optic trunk circuit.

Haliplex modules that can be used as Synchronous Trunks in this category are;
 HPX-IIM-1620-E1 Dual E1
 HPX-IM-1620-T1 Dual T1
 HPX-IM-1614 Low Speed Fibre (2x E1)

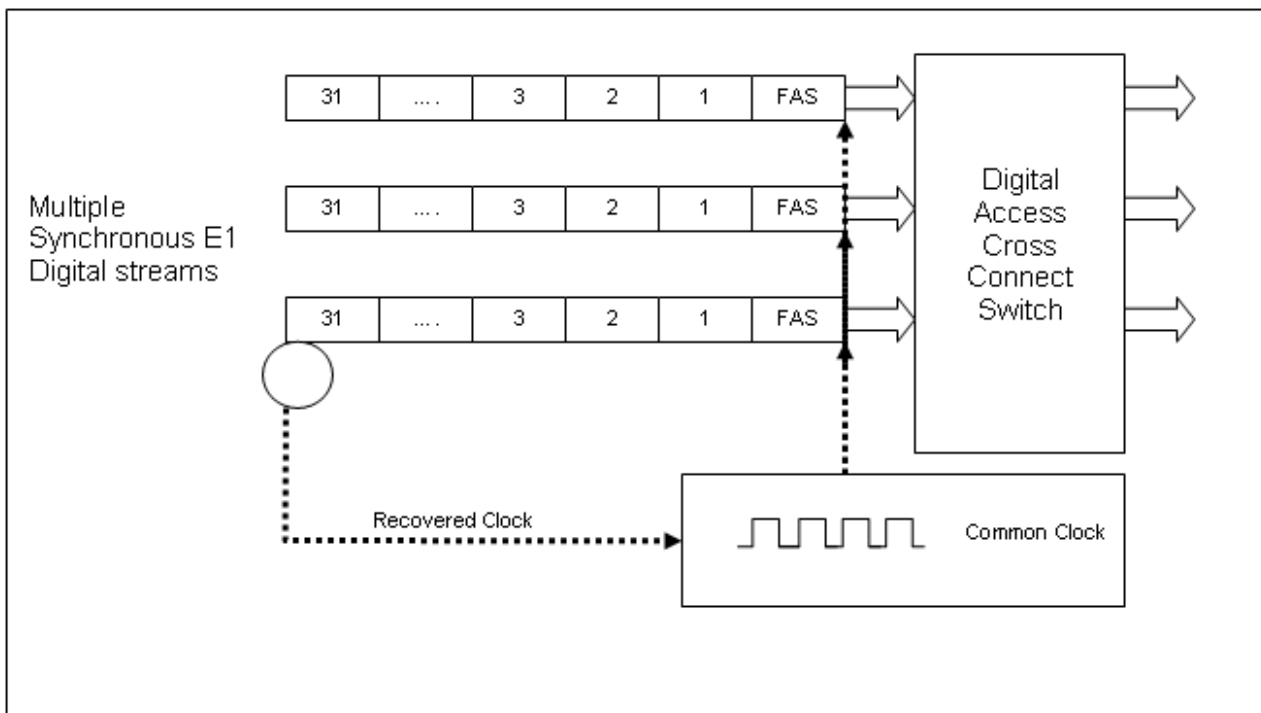


Figure 1: Synchronous trunk circuits

3.2. PLESIOCHRONOUS E3/T3 TRUNKS

The fibre optic trunk interfaces described in the previous section operate with only synchronised tributary circuits and cannot be used to multiplex unsynchronised tributaries that may originate from multiple networks each with independent clock sources.

Where multiple unsynchronised tributaries are multiplexed, the industry proven PDH (Plesiochronous Digital Hierarchy) standards can be applied to multiplex many E1/T1 asynchronous tributary circuits over a common synchronous trunk circuit. Each tributary is carried with independent clocking end to end over the PDH trunk with buffering and bit stuffing techniques applied to reproduce the asynchronous tributary at the far end. Each multiplexer trunk operates with an independent transmit clock which is recovered by the receiver circuit of the remote node.

The HPX-1600-EM multiplexer operates with an E3/T3 (34Mbps/45Mbps) trunk and supports up to 16xE1/28xT1 asynchronous tributary circuits. Synchronous tributary circuits and DACS features are not supported by the HPX-1600-EM.

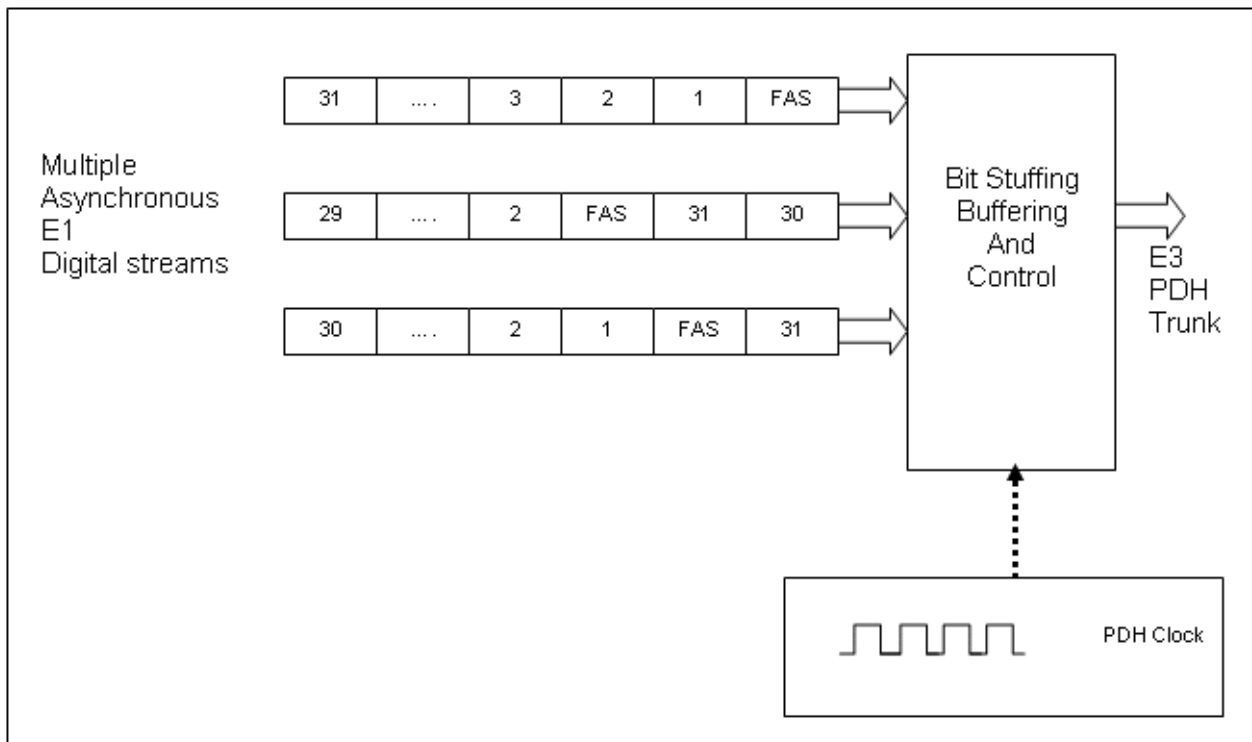


Figure 2: Asynchronous circuits over PDH trunk

3.3. SYNCHRONOUS DIGITAL HIERARCHY (SDH) / SONET TRUNKS

The Haliplex HPX-1600-SS SDH/SONET multiplexer supports both synchronous and asynchronous tributary circuits. The SDH/SONET timing exists independently of the tributary interface timing, and uses pointer adjustment techniques to provide independent timing for all of the independent payloads contained within the SPE. (Synchronous Payload Envelope). This flexibility allows both Synchronous and Asynchronous tributaries to be transported across the SDH/SONET network, without the SDH/SONET network needing to know about it.

As a general guide, interfaces connected directly to the SDH/SONET run asynchronously. Interfaces or SDH/SONET connections to a DACS operate synchronously.

- Fibre optic trunk connections that use the **LSF** (HPX-IM-1614) to map E1 circuits from the SDH/SONET trunk to a HPX-1600-IA multiplexer, operate in **synchronous** mode.
- Fibre optic trunk connections that use the **HSF** (HPX-IM-1610) to map E1 circuits from the SDH/SONET trunk to a HPX-100 multiplexer, operate in **asynchronous** mode.

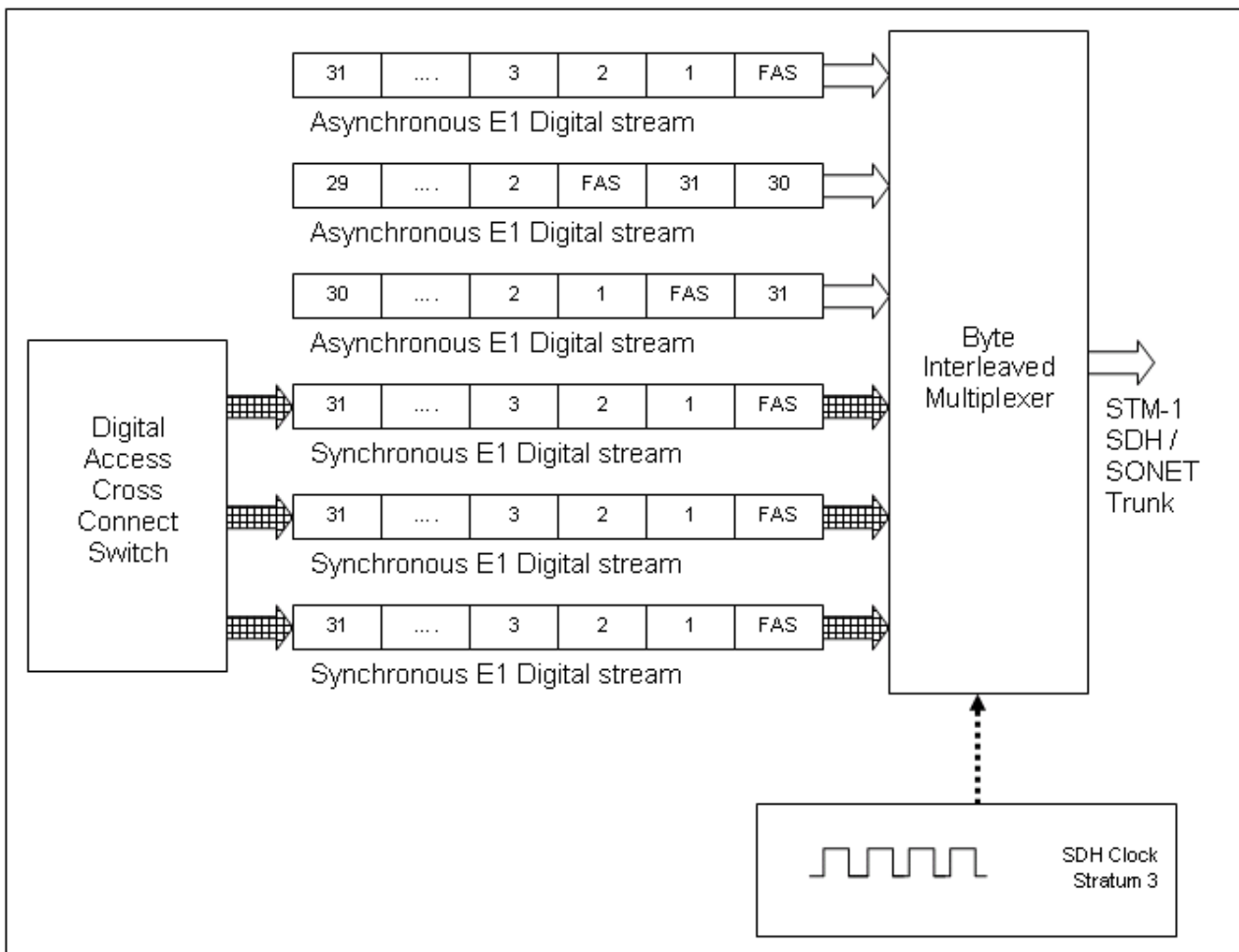


Figure 3: SDH / SONET Trunk

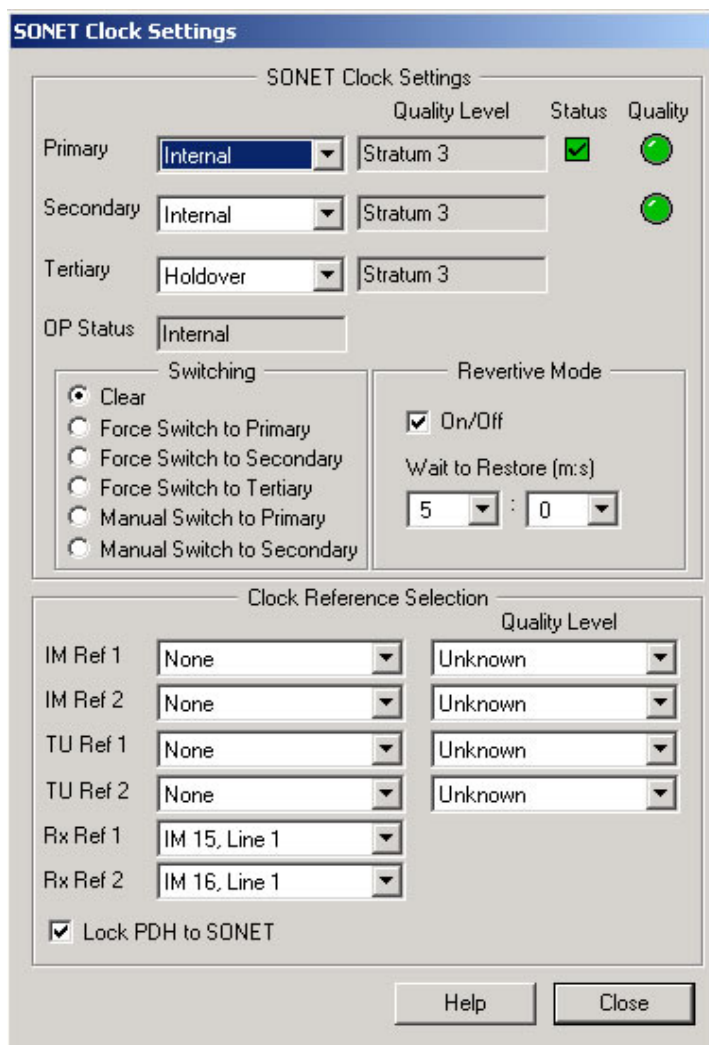
4. NODE CLOCKS

A network of Haliplex multiplexer nodes connected with synchronous, PDH or SDH trunk circuits must be planned to include a clock synchronisation architecture. Each Haliplex HPX-1600 multiplexer supports the capability to operate from an internal clock source or to synchronise to one or two external clock sources.

4.1. SYNCHRONOUS NODE CLOCKS

The HPX-1600-IA operate with synchronous trunks. All connected network nodes must operate with a node clock that is synchronised to a common network clock source. The IA series contain an internal Phase Locked Loop clock that can be locked to either an internal 8KHz crystal referenced clock or an external clock source. The internal clock has a accuracy of 20ppm. An external clock source can be any synchronous trunk with recovered clock timing. Each network node can be configured with automatic quality detection and automatic switching between the three clock sources.

The quality indicators show green or red in colour for acceptable clock standards for each of the selected Primary and Secondary sources.



The green status tick indicates the active clock selection and the “OP status” either “Locked” or “Free Running” status.

A switchover to an alternative clock source can automatically revert to the Primary clock when the received clock quality returns to within specifications.

External clock sources can be selected from a recovered clock of any E1/T1 or fibre optic trunk.

Figure 4: IA/OM Clock settings

A single network clock source can be propagated through the network.

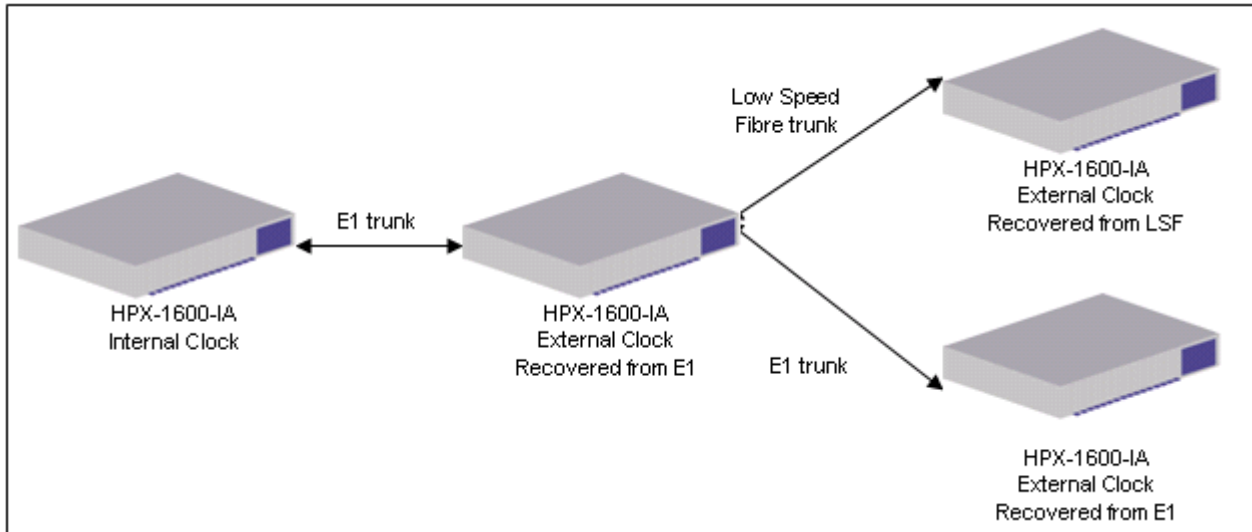


Figure 5: Propagated Network Clock

4.2. PDH NODE CLOCKS

The E13 Multiplexer is installed in pairs linked by an E3/T3 PDH trunk circuit. The PDH multiplexer transports only asynchronous tributaries and does not support synchronous components such as a DACS. Because the E3 framing structure accounts for the timing of the individual E1 payloads independently in both directions, a networked pair of E13 MUX can each be set to “internal” clock, which is recovered at each remote end.

A Synchronous network of HPX-1600-IA nodes can be trunked using the asynchronous tributaries of the E13 MUX, as they only pass through the node without being demultiplexed to gain access to the DS0’s. The IA payload timing is maintained. (see figure below).

E13 MUX node clock configuration setting is the same as for the IA products.

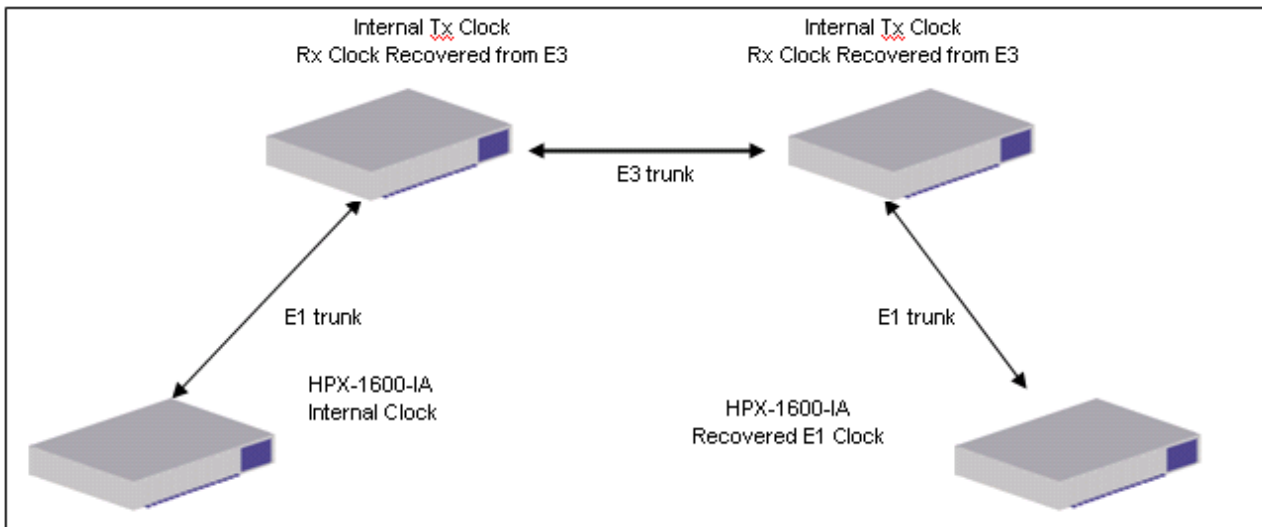


Figure 6: Synchronous network over an Asynchronous trunk

4.3. SDH NODE CLOCKS

The Haliplex HPX-1600-SS, SDH/SONET access multiplexer combines the features of an Add Drop Multiplexer and a Synchronous Digital Access Cross-Connect. As such the HPX-1600-SS supports two independent clock schemes.

- SDH/SONET
- PDH system clocks for the DACS.

The HPX-1600-SS can be used to generate a “master” network clock using the integrated stratum 3 (4.6 ppm) clock. Alternatively the clock may be recovered from the working or protection STM-1/Oc-3 trunks or any E1/T1 interface sourced from a stratum 3 or better clock source.

The integrated DACS can be synchronised using the internal 8KHz clock, or a recovered clock from a synchronous tributary. Synchronous tributaries can be E1/T1 interfaces or from the SDH/SONET trunk, designated (virtual) tributary units.

Both SDH and PDH clock systems operate in a similar but slightly different manner. Up to three clock sources can be configured which will be selected sequentially on loss of the other specified clock sources. If a revertive option mode is selected then the clock source will return should a previously lost clock return to a stable and acceptable state. Both SDH and PDH clock settings offer a selection of Primary, Secondary and Tertiary sources. On the PDH side, should all external references be lost the clock will switch to “Freerun” using the internal 8KHz clock. For the SDH clock, the option exists on loss of all external clocks to switch to “Holdover” which maintains the clock at the last known reference frequency and phase.

The flexibility in clock architectures features by the HPX-1600-SS, enables the support of many diverse network solutions.

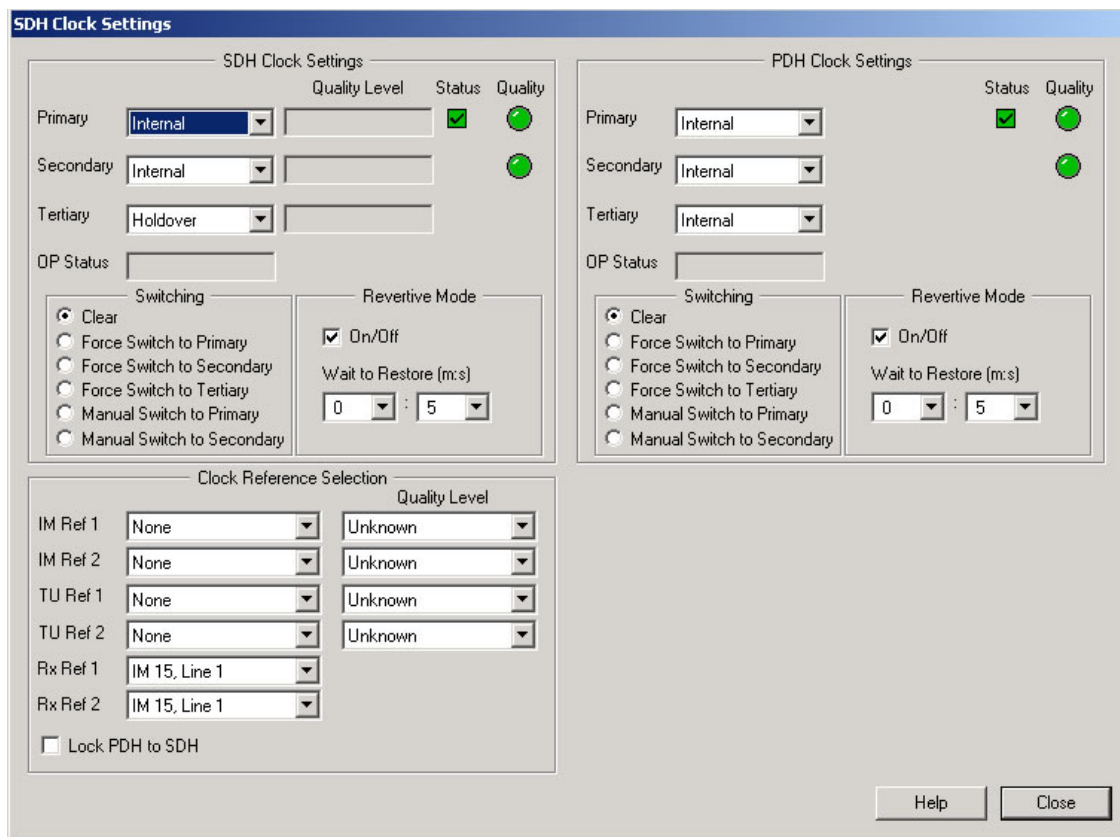


Figure 7: HPX-1600-SS - SDH/SONET & PDH clocks

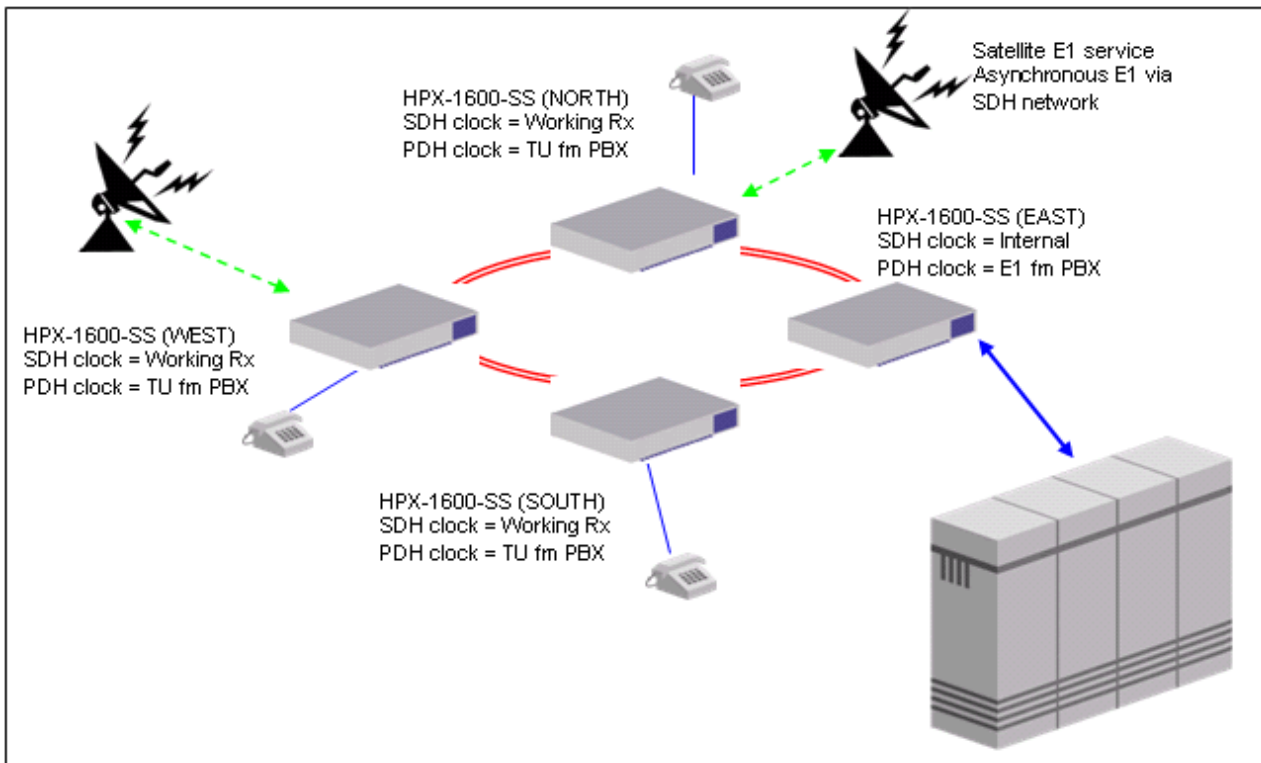


Figure 8: Combined SDH and PDH clocked network

A simple example of a diverse clock network is shown in figure 8.

Nodename	Clock sources	Tributaries
EAST	HPX-1600-SS	
	SDH clock internal	
	PDH clock E1 from PBX	
		E1 from PBX mapped to DACS and tributary E1 containing voice circuits mapped over Tributary Units to the WEST, NORTH and SOUTH nodes
SOUTH	HPX-1600-SS	
	SDH clock working Rx	
	PDH clock TU from EAST	
		TU from EAST mapped to DACS
		Voice FXS interfaces mapped to DACS
NORTH	HPX-1600-SS	
	SDH clock working Rx	
	PDH clock TU from EAST	
		TU from EAST mapped to DACS
		Voice FXS interfaces mapped to DACS
		E1 satellite service mapped over Asynch over the SDH ring to WEST
WEST	HPX-1600-SS	
	SDH clock working Rx	
	PDH clock TU from EAST	
		TU from EAST mapped to DACS
		Voice FXS interfaces mapped to DACS
		E1 satellite service mapped over Asynch over the SDH ring to NORTH

Table 1: SDH/PDH network clock example

5. CLOCK QUALITY

Each configured alternative clock source for SDH/SONET and PDH is assessed for acceptable quality before being considered as an active clock source. The pass/fail result of the clock quality test is indicated by the green or red indicator next to the clock source graphic. The clock quality acceptance criteria for PDH, is +/- 100 ppm and for SDH/SONET more stringent at +/- 12 ppm.

The SDH/SONET clock source is also ordered by the defined quality level or the clock. In the case of all clocks meeting the quality acceptance standard, the clock source defined as being from the highest quality level will be selected.

Clock Source Quality	SDH	Reference ITU standard	SONET	Definition Stratum Clock (ppm)
From highest to lowest ↓	Primary Ref Clock	(G.811)	Stratum 1	0.00001
	Synchronisation Supply Unit Transit	(G.812)	Stratum 2	0.016
	Synchronisation Supply Unit Local	(G.812)	Stratum 3	4.6
	SDH Equipment Clock	(G.813)	+/- 20 ppm	20
	Do Not Use		Do Not Use	

Table 2: SDH / SONET clock quality

Where the clock source is an external interface (HIM Ref 1 and HIM Ref 2), the network administrator must manually configure the clock quality associated with the interface. The reference “Do Not Use” is a quality level automatically generated by the HPX-1600-SS to prevent the occurrence of timing loops within the network or other forms of poor clock reproduction.

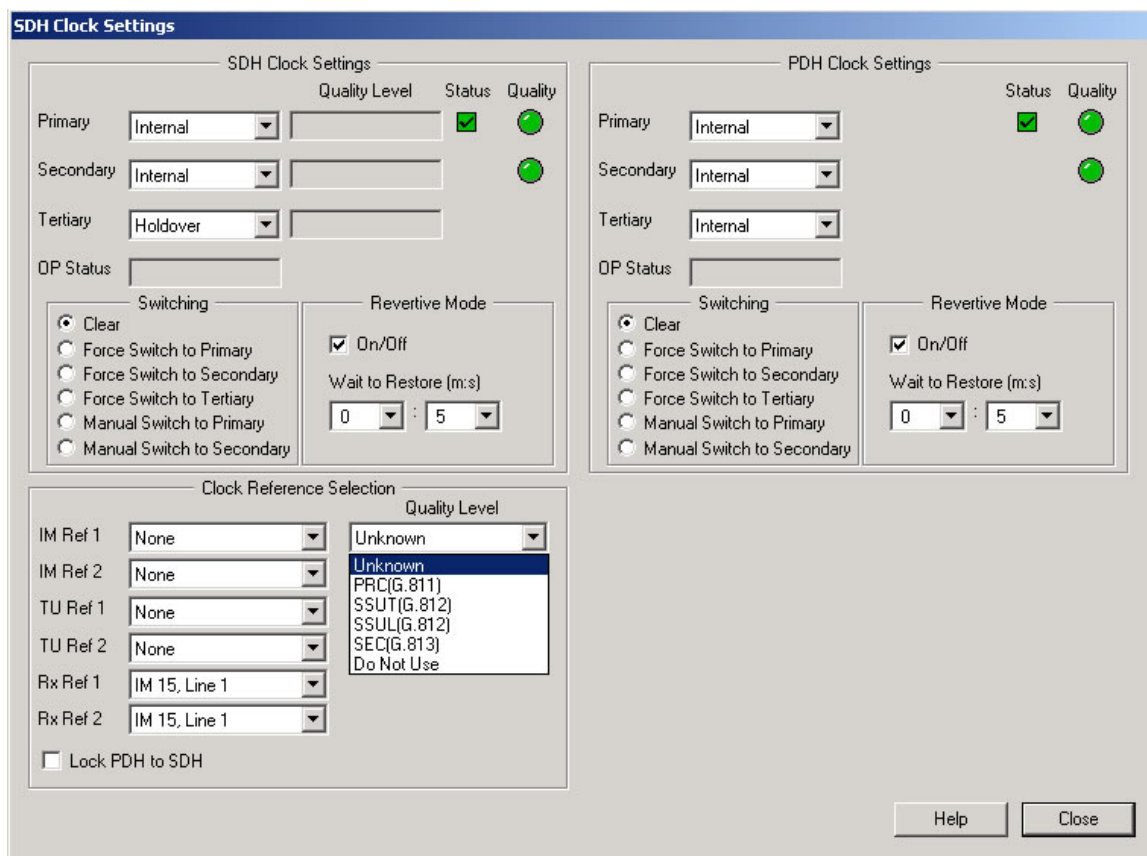


Figure 9: Clock Quality: SDH & SONET

6. NETWORK SYNCHRONISATION

The previous sections of this chapter have dealt with the differences with respect to clocks in the types of tributaries and trunks supported by Haliplex multiplexers. While it is a simple matter to configure an alternative clock source on each network node in isolation it can be significantly more difficult when designing an architecture for resilient clock synchronisation over an entire network.

6.1. NODE SYNCHRONISATION

First design your network with a common clock reference.

Is there an external clock reference that generates a clock that meets specifications and is synchronised to the data ? Examples are;

- STM-1/Oc-3 connection to higher order network
- E1/T1 connection to a PBX
- E1/T1 connection to a higher order network

Having selected the network clock source, now distribute the clock over the trunk circuits so that you avoid timing loops. A timing loop occurs when the same clock source is regenerated through multiple paths to the same target node. Clock distribution is best designed as a tree structure, radiating from a trunk out through multiple branches, each branching into smaller branches.

6.2. ALTERNATIVE CLOCKS

The first question to consider is; “Do I need an alternative clock reference?”.

Consider the following situations for which a single clock reference is adequate and make sense;

- A point to point, two node network.
- A multi node network connected with single trunks, with a single head end node through which all traffic is routed.

Alternative clocks should be chosen such that they make sense. All clock sources should be synchronised with the transmitted data. In the event of failure of the primary clock, there should a reasonable expectation that the secondary clock will remain available.