Why Synchronize?

Synchronous versus Asynchronous

Traditionally, transmission systems have been asynchronous, with each terminal in the network running on its own clock. In digital transmission, “clocking” is one of the most important considerations. Clocking means using a series of repetitive pulses to keep the bit rate of data constant and to indicate where the ones and zeroes are located in a data stream.

Since these clocks are totally free-running and not synchronized, large variations occur in the clock rate and thus the signal bit rate. For example, a DS3 signal specified at 44.736 Mb/s + 20 ppm (parts per million) can produce a variation of up to 1789 bps between one incoming DS3 and another.

Asynchronous multiplexing uses multiple stages. Signals such as asynchronous DS1s are multiplexed, extra bits are added (bit-stuffing) to account for the variations of each individual stream, and are combined with other bits (framing bits) to form a DS2 stream. Bit-stuffing is used again to multiplex up to DS3. DS3s are multiplexed up to higher rates in the same manner. At the higher asynchronous rate, they cannot be accessed without demultiplexing.

In a synchronous system, such as SONET, the average frequency of all clocks in the system will be the same (synchronous) or nearly the same (plesiochronous). Every clock can be traced back to a highly stable reference supply. Thus, the STS-1 rate remains at a nominal 51.84 Mb/s, allowing many synchronous STS-1 signals to be stacked together when multiplexed without any bit-stuffing. Thus, the STS-1s are easily accessed at a higher STS-N rate.

Low-speed synchronous virtual tributary (VT) signals are also simple to interleave and transport at higher rates. At low speeds, DS1s are transported by synchronous VT-1.5 signals at a constant rate of 1.728 Mb/s. Single-step multiplexing up to STS-1 requires no bit stuffing and VTs are easily accessed.

Pointers accommodate differences in the reference source frequencies and phase wander, and prevent frequency differences during synchronization failures.

Synchronization Hierarchy

Digital switches and digital cross-connect systems are commonly employed in the digital network synchronization hierarchy. The network is organized with a master-slave relationship with clocks of the higher-level nodes feeding timing signals to clocks of the lower-level nodes. All nodes can be traced to a primary reference source, a Stratum 1 atomic clock with extremely high stability and accuracy. Less stable clocks are adequate to support the lower nodes.

Synchronizing SONET

The internal clock of a SONET terminal may derive its timing signal from a Building Integrated Timing Supply (BITS) used by switching systems and other equipment. Thus, this terminal will serve as a master for other SONET nodes, providing timing on its outgoing OC-N signal. Other SONET nodes will operate in a slave mode called “loop timing” with their internal clocks timed by the incoming OC-N signal. Current standards specify that a SONET network must be able to derive its timing from a Stratum 3 or higher clock.