RALTRON

Technical Notes

December 12, 1999
D. Habic
T. Raphaely

Product and Technology Application Notes

SY-0001B Synchronous Equipment Clock / Stratum 3 Clock Unit

Introduction

The main focus of this application note is to inform marketing and sales people about the Synchronous Equipment Clock, Raltron Model SY-0001B, and it's applications, potential markets, and how the unit should be specified.

What is Network Synchronization?

"*Network Synchronization*" is the means of ensuring that the signals of an entire digital network are effectively clocked or synchronized by a single, well-defined set of related frequencies. In practice, this involves the planning, designing and operation of each network and sub-network to have all their systems / subsystems clocked at the same average rates and with an accuracy which is traceable to Universal Time Coordinate (UTC).

Why a Synchronous Network?

Digital services require real time end-to-end bit integrity, without any unnecessary signal delays. The cost-effective method of meeting these demands is to make all interconnected networks operate as one synchronous network, by limiting sub-networks to operate at the same nominal frequency and within a well defined tolerance.

What is a Clock?

Clocks are devices used to provide timing and synchronization information to the equipment elements of a digital transmission system or network. Clocks are embedded within switching or transport equipment or in stand-alone synchronization equipment, such as, Timing Signal Generators (TSGs) and Primary Reference Sources (PRSs). They are generally interconnected in a hierarchical fashion by the digital facilities of the synchronization network. The interconnection of the clocks assures that normally (no facility failures) all the clocks are synchronized such that they are all operating at the same average frequency.

What is the Interconnection Hierarchy?

The interconnection hierarchy arranges the clocks in a master-slave order with the clocks of highest performance at the top of the hierarchy and clocks at lesser levels, called Stratum Levels, of performance at the lower levels of the hierarchy. The master clock at the top of the hierarchy is called a Stratum 1 or G.811 clock and is embedded within a Primary Reference Source or a Primary Reference Clock. The slave clocks at the lower levels of the hierarchy are called Stratum 2, 3E, and 3, for example, and are designed to be always connected to an upstream clock so that its average output frequency is equal to that of the input.

Characterizing the Clock?

There are various aspects of clock performance that relate to its function in the synchronization network and most of which characterize the departure of significant timing instants from those of an ideal reference source. One of the performance measures is average frequency accuracy. All parameters and behavior that characterize the clock are well defined and specified by international standards. The common standards that describe in detail, are Bellcore (North American) and ITU-T (European).

What is the Clock Accuracy?

Clock accuracy is defined as the level of agreement of the frequency of a clock with the ideal frequency. It is specified as the magnitude of the fractional frequency offset from the ideal frequency. The fractional frequency offset is defined as the difference between the actual and ideal frequency divided by the ideal frequency. The frequency in this definition is generally the frequency averaged over a sufficiently long observation time to adequately determine the frequency. Typically, for these applications, this observation time may be on the order of one hour to one day. The relevance of clock accuracy to its performance within a digital synchronization network depends on its place in the hierarchy.

What is the accuracy of Primary Reference Clocks?

For the Primary Reference Clocks at the top of the hierarchy, the accuracy of these clocks must be good enough so that the data performance of traffic passing between networks timed by different independent PRS's meets certain thresholds. This accuracy limit for these Stratum 1 clocks is well established at 1×10^{-11}, which is equivalent to one part in 10^{11}, with respect to Universal Time Coordinated (UTC). This accuracy limit for PRSs applies for normal operation continuously over the lifetime of the equipment. PRS's are in the free-run mode, since they are at the top of the hierarchy and are in this sense, autonomous. This also applies for PRS's that use radio navigation signals, such as, GPS, to employ direct control from UTC-derived frequency and time services. These clocks are specified in ANSI T1.101 (Stratum 1) and in ITU-T G.811, and generic requirements for these clocks are in Bellcore GR-2830-CORE.

What is the accuracy of Slave Clocks?

For slave clocks, the situation is quite different. These are the clocks that are normally synchronized to another clock of equal or higher level, and are normally traceable to a Primary Reference Clock at the top of their synchronization path. These clocks are known as stratum 2, 3E, 3 and transit node and local node clocks. The Stratum clocks are specified in T1.101 and the transit node and local node clocks are specified in G.812 that includes all of these slave clocks.

What are the Modes of Operation of One Slave Clock?

There are three modes of operation of these slave clocks: **normal** (synchronized), **holdover**, and **free-run**, plus possibly some special cases of transition between these modes. In the **normal** mode, the long-term average accuracy of the clock is equal to that of its synchronization source, which is normally one part in 10^{-11} or better. The **holdover** mode is the operating condition of a clock that has lost its controlling input and is using stored data acquired, called history, while in normal operation to control its output frequency. The accuracy of a good clock in the holdover mode starts out equal to the normal mode accuracy, and over time may slowly drift from this frequency as determined by the stability of the clock's internal oscillator.

The **free-run** mode is the operating condition of a clock whose output is totally internally controlled. The clock has never had, or has lost, all external reference input, and has lost all data from a previously connected source. This may be the condition of a clock newly turned-on, or else a clock which has been in holdover for an extremely long time. The specifications for free-run accuracy apply over the lifetime of a clock, typically for 20 years. The need for specifying free-run accuracy is to enable the specifying of pull-in ranges of slave clocks to assure that, under worst-case conditions of lost reference sources for an extremely long time, the frequency of a clock cannot drift beyond the pull-in range of the downstream clock. The need for specifying free-run accuracy is to enable the specifying of pull-in ranges of slave clocks to assure that, under worst-case conditions of lost reference sources for an extremely long time, the frequency of a clock cannot drift beyond the pull-in range of the downstream clock.

What is Accuracy of in the Holdover Mode or…?

One of the main points to consider is how long in practice can a slave clock remain without a reference? This, of course, is determined by the operational methods of the network provider. Some have said 5 days is the longest time a clock could remain without a reference, others have said a little longer, maybe 8 days. The following calculated values show how far off-frequency a clock could, in the worst case based on existing T1.101 specifications, be after 1 day without reference input:

Stratum Level	Free-Run Accuracy	Holdover Accuracy after 1-day
2	1.6×10^{-8}	1×10^{-10}
3E	4.6×10^{-6}	1×10^{-8}
3	4.6×10^{-6}	3.7×10^{-7}

Where is the Market?

The best market are in those applications related with Stratum 3 and in the near future, Stratum 3E. Typically, Stratum 3 applications encompass communication and data network equipment. Moreover, the fast growing SONET (Synchronous Optical Network) applications are good opportunity for synchronization equipment. Some of the SONET applications require SONET Minimum Clock (SMC) that is different type of clock then Stratum 3. Obviously, there is decent amount of small and medium sized company recently established, that because of limited internal resources, want to use SMC that will save time and money and still offer good performance. Because of critical time-to-market most companies look for integrated solutions for synchronous clocks that will be appropriate for their application and the SY-001B is designed for both SMC and Stratum 3 applications. The SY-0001B helps network engineers address frequency control, nanosecond processing, jitter and wander issues, and it is all within one board level module.

What is Raltron Electronics doing for that Market?

Recently, Raltron Electonics decided to step gradually into the synchronous clock and Stratum 3 market. Actually, this product is just an extension of the current product line. Basically, the synchronous clock will utilize different kinds of Raltron oscillators, namely an OX5000 and a VC800. Since late spring of this year, Raltron Electronics has been developing a synchronization clock module SY-0001B that can easily fit into customer's Stratum 3 and SMC applications. In addition, Raltron plans to develop the more accurate clock modules for Stratum 3E applications during the second quarter in year 2000.

What is SY-0001B?

The SY-0001B is an accurate time and frequency source that has been designed as a module level subsystem for easy incorporation into ATM, SONET, SDH, wireless systems or any other systems where synchronization is tantamount. The SY-0001B is an advanced synchronization solution for the timing needs of digital telecommunications, jitter and wander issues in accordance with ITU-T Recommendations G.813 and BellCore GR-1244-CORE, and the maintenance of end to end network performance.

How the SY-0001B can be utilized in an application?

Basically, SY-0001B is used on a customer's clock board as a module or sub-system. The SY-0001B module accepts four types of input signal, for example, T1, E1, SONET, and GPS that are usually resident within the network system. These input signal interface and connect the physical layer of the network to the SY-0001B module. The network interface consists of line interfaces, receivers, and transmitters usually implemnted in an intergrated circuit.

The simplified operation is as follows:

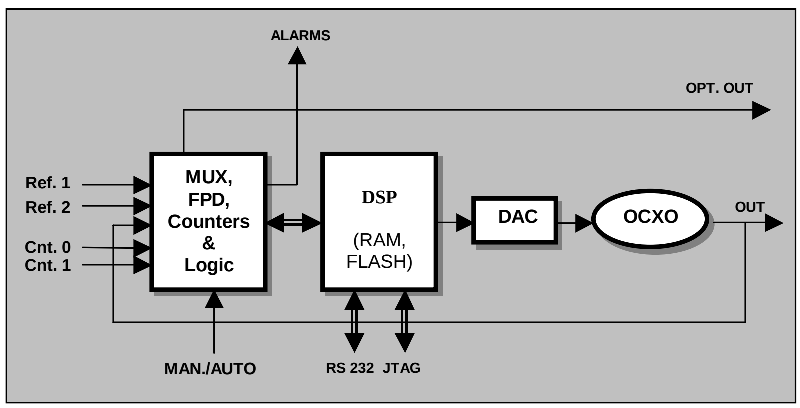
The receiver in the interface takes data patterns from network. and extracts the clock signal that will be used as the input reference for SY-0001B. The SY-0001B generates a new clock signal that supplies the transmitter IC of the interface. The new clock signal is now used as the master clock signal for this particular network element.

How does SY-0001B operate?

The SY-0001B Synchronization Module is a Digital PLL (DPLL) which utilizes application specific software in the digital signal processor (DSP).

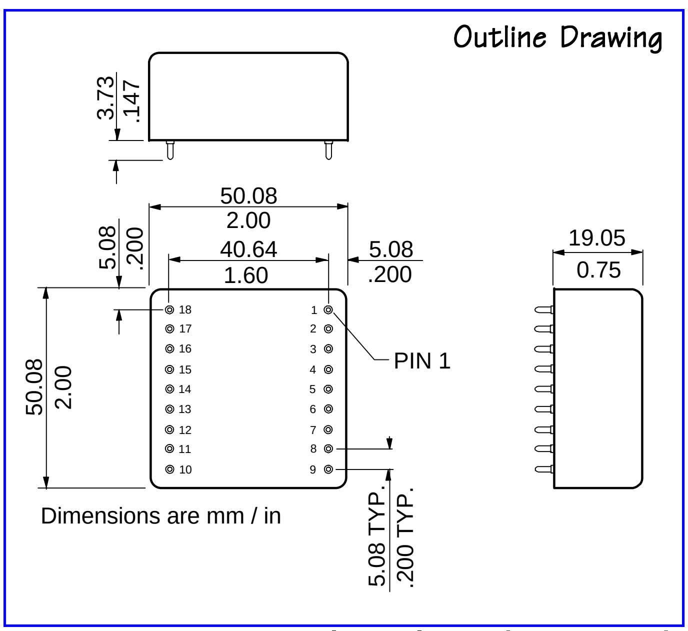
The SY-0001B provides several key features:

- Monitors the input references using an allocated memory buffer that estimates the signal existence and its quality.
- Real time calculation of the filtering algorithm for jitter and wander in accordance with approved standards (ITU-T and Bellcore).
- Alarm, status and messaging functions.
- Controlling the internal references for frequency versus temperature, aging, and calibration effects.



From the simplified block diagram shown the unit operates in four working modes:

1- Free running
2- Hold-over (both locked to internal OCXO)
3- Slaved to Input Reference 1
4- Slaved to Input Reference 2



Typically, the unit has to change timing modes in response to external events. Two types of mechanism are offered to select between timing modes:

1- Autonomous mode performing in accordance with the program.

2- Manual selection is performed via controls consistent with the user system (Cnt. 0 and Cnt. 1). Both mechanisms can be selected by setting the jumper (MAN/AUTO) on the module.

Raltron Electronics Corporation 10651 NW 19th St. Miami, Florida 33172 U.S.A.
Tel: 305-593-6033 Fax: 305-594-3973 e-mail: sales@raltron.com Internet: http://www.raltron.com