Tech Notes

Technical Application Note

Synchronizing Signals Over a Satellite Link

It is often desirable to synchronize data signals over a satellite link. Many satellite links may connect a telephone or a computer to a hub site and require minimal synchronization effort. Many other links however are part of a large network which may be disparate, having different or the same very accurate clock available at both ends.

Typical Link Synchronization

First it should be noted that it is not difficult with most modems to transfer the basic clock accuracy available at one end of a link to the other. Locking the modulator data rate clock at the source end to the accurate clock source does this. The receive clock at the other end then maintains this accuracy, but with the unfortunate addition of the satellite induced Doppler shift. Many receive sites have no problem accepting the Doppler shifted clocks and using them in the DTE equipment. The Doppler shift itself can be removed if a sufficiently accurate clock is available at the receive end by using the Doppler or Pleisosynchronous buffer available in many modems.

One typical implementation of this is called "Loop Timing" where one end is determined to be the "Master" because it has the master clock source. This clock source is provided to the send timing by applying the clock to the "Terminal Timing" (TT) input on the data interface connector. Note that the send timing itself is always an output from the modem, and the TT input signal is used to synchronize the send timing signal. The receive timing at the opposite link end now has the same timing with added doppler shift. If this end uses the receive timing to derive the send timing for data back to the master, either in external equipment or by modem settings, then this is referred to as "Loop Timing" because the timing goes from the master to the remote, is looped at the remote and returns to the master. The receive timing at the master will have doppler shift, but it can be removed by setting the doppler receive buffer to use the original transmit clock as the buffer output clock.

Another typical synchronization implementation is called "Master-Slave". In this scheme both ends are masters for the send timing and slaves to the receive timing. If the data rates in each direction are different this may be the only easily implemented method. The modem itself can provide the send timing reference, or it may be supplied by an external terminal timing clock.

Tougher Link Synchronization

A more difficult case arises when there is a "network" on both ends of the link, and the network has its own accurate clock source. One purpose of this tech note is to show the proper method of accomplishing this with Datum System modems, and show some of the pitfalls that should be avoided.

Two methods are available to synchronize modem clocks to an external reference. First is the Terminal Timing input available on the data interface. The data interface send timing clock is always an output from the modem used to clock the "Transmit" data into the modem. When the

Terminal Timing (TT) clock is present and the modem is configured to use this as the send timing source then the transmit data rate clock is locked to the TT signal. The TT signal must be at the same rate as the desired data rate clock.

The second method available is the "External Reference" which replaces the modem's internal reference. This reference is used to synchronize all of the modem's internal clock generation. This can guarantee that the modems transmit signal and data rate clocks share the same stability as the external reference.

The method used to generate those internal clocks however can lead to misunderstanding about the accuracy of those clocks, and thus errors in synchronizing the data rate clocks. Most modern modems use Numerically Controlled Oscillators (NCO) to set the synthesizers used to generate the IF local oscillators and the data rate generators. The NCO is digitally set to a frequency with a certain number of control bits. In the case of the PSM-512, PSM-1500 and PSM-2100 modems, 18 bits are used to set the oscillator frequency. The basic "settability" is then 1 in 2^{18} (plus some other factors too complex to discuss here). The oscillator can then be set to within approximately 5 parts per million (5 ppm) of any data rate (at FEC rate ½, or 10 ppm at FEC rate ¾ or 7/8). While this is extremely accurate it is not exact for all data rates, and no matter how accurate the reference signal may be, certain data rate clocks will fall toward this outer limit of 5 ppm in absolute accuracy.

What does this mean when setting up a link where absolute synchronization between the transmit and receive data rate clocks is desired? It means that the clock synchronization method should be the same on both ends of the link. This insures that any innacuracy in setting the clock at one end of the link is repeated at the other end. Note that this is only necessary if an approximate same accuracy clock source is available at both ends of the link. An example is in order here:

Link Synchronization Example

Case 1 - Consider a system with a cessium or rubidium standard that is available at all sites. The transmit clock at site "A" is locked to an external Terminal Timing clock which is in turn rate locked to the site standard. If Site "B" receives the signal from site "A" then its receive data rate clock will share the accuracy of site A's transmit clock, but have Doppler shift added to it. The Doppler buffer at site B should then use one of two methods to clock the data out of the Doppler buffer:

1. Use the same terminal timing method where the TT signal is rate locked to the local standard. The modem buffer then is set to use the Modulator clock as its output clock source.
2. Or use the data rate locked data timing signal directly as the source of the buffer output clock by applying this signal to the "external buffer" pins on the data interface and setting the buffer output source to "External".

Case 2 - If instead site A used the "External Reference" to lock the modems signals to the accurate standard, then Site B should also use the "External Reference" to insure that the same "settability" error is present at this site. The site B receive buffer can then use the modulator clock as its output clock source. Note that the use of one synchronization method as in Case 1, does not preclude also using the external reference to insure that the transmit IF signals are very stable.

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