The PicoPak Lock Acquisition Process and Frequency Tracking

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The PicoPak Clock Measurement Module must acquire phase lock between its externally-referenced DDS synthesizer and the applied RF signal before it can begin to make measurements. This lock acquisition process involves setting the DDS frequency closely to that of the signal so that the phase lock loop can establish a stable quadrature condition between the DDS output and the signal. During measurements, the unit may need to track changes in the source frequency.

The DDS frequency can be set either to the nominal frequency entered by the user or automatically by measuring the signal frequency with respect to the external reference. The former method is the more straightforward and is preferred when the signal frequency is known to an accuracy of several $pp10^9$ or better. For example, many precise clocks operate at very close to exactly 10 MHz, and that value can be entered as not only as the nominal frequency for determining fractional frequency deviations but also to set the DDS frequency. But if the exact signal frequency is unknown, the PicoPak module uses a 2-step process to measure it closely enough for the unit to achieve lock. The latter method is the default, but it can be changed to use the nominal frequency value by checking the Use Nom Freq to Acquire Lock checkbox in the Processing section of the Configure screen, or by manually setting the UseNomFreq flag in the [Preferences] section of the PicoPak.ini configuration file.

The automatic frequency acquisition process begins by making a 1-second gate time frequency counter measurement that determines the signal frequency to within about $\pm$10 Hz. That is subject to small measurement-to-measurement variations and systematic errors. These can be reduced by trimming the PicoPak's microcontroller clock rate [1] and by applying a calibration factor [2]. If the bVerbose flag is set in the PicoPak.ini configuration file, the approximate signal frequency is shown in the message area of the PicoPak Windows® graphical user interface application during lock acquisition. That is followed by setting the DDS to establish a beat note of approximately 100 Hz between it and the signal, and making a period measurement to determine the signal frequency with a resolution of 10 mHz ($1pp10^9$ at 10 MHz). That value is shown as the measured signal frequency, and is used to set the DDS for lock acquisition. If the DDS setting is not as close to the signal frequency as possible, the < and > controls can be used to adjust it.

Otherwise, if Use Nom Freq to Acquire Lock is checked, the nominal frequency value is used to set the DDS.

The PicoPak should then acquire phase lock. Phase lock is confirmed by measuring the phase detector voltage, which must be about 1.664 VDC. This check is done several times to make sure that it not only has the right nominal value but that it is stable. Those measurements are also shown as messages during lock acquisition (one for each check if bVerbose is set).

During operation, the PicoPak tracks the phase variations between the signal and the externally-referenced DDS. Because the DDS has a finite frequency offset, there will be a phase ramp in addition to the phase noise fluctuations. If the source frequency changes, so will the slope of the phase ramp change. If that slope exceeds a certain value, the DDS frequency can automatically be adjusted to maintain phase tracking. Those adjustments are enabled or disabled with the Freq Adjustments checkbox in the Processing section of the Configure screen, and their size can be set with the Step Size edit box (1-3 DDS tuning increments). A larger value may be needed if the source has large frequency variations (limited to about $\pm 3 \times 10^{-8}$/s). If those variations become very large, phase lock may be lost. In that case, the message box will indicate No Data, but previous data will not be lost. A Freq Adj indicator on the main screen shows whether frequency adjustments are enabled, and an audible beep indicator for frequency adjustments can be enabled with the Beep checkbox.

References:

1. W.J. Riley, "Trimming the PicoPak Microprocessor Clock Frequency", Hamilton Technical Services, Beaufort, SC 29907 USA, September 2015.
2. W.J. Riley, "Trimming the PicoPak Signal Frequency Measurement", Hamilton Technical Services, Beaufort, SC 29907 USA, September 2015.