Frequency/ Phase Difference Comparator

Are you worried about ranges, counter overflows and whether the inputs are of true instrumentation quality?, well Quartzlock(UK) Ltd just might have the piece of equipment you have been looking for. The Quartzlock model A7 Frequency and Phase Comparator is a state-of-the-art computer based very high-resolution frequency and time interval measurement system. The Quartzlock A7 is unique in being able to combine the most advanced technologies from Britain, Russia and the USA to make an instrument comparable, if not better than anything found elsewhere in the world. In addition to being supplied with a rubidium frequency standard as a reference, the A7 may also be combined with the hydrogen maser frequency standard (another British-Russian collaboration) to achieve unparalleled 1.5E-15 resolution and 1E-14 accuracy. Yet, through the combination of comparator, time interval counting and MATHCAD/Stable32 software, the A7 is remarkably easy to use and will reduce the time needed for measurement drastically.

This all sounds great I hear you say, but how does the A7 actually achieve such remarkable results? It is based around a frequency multiplier unit made by IEM KVARZ in Russia. This unit takes two 10MHz (or 5MHz) signals and multiplies their frequency difference by 1000 or 10000. It then outputs a 5MHz sine wave with the frequency difference (multiplied by 1000) superimposed. It also outputs a 1Hz pulse with the frequency difference (multiplied by 10000) superimposed. The rest of the circuitry in the A7 is concerned with providing a 10MHz reference signal to the counter, providing a 1Hz reference signal and providing level monitoring and switching.

It is the quality of the frequency multiplier unit that is the key to the performance of the A7. In order that the reader gains insight into this unit, a detailed description will follow. The A7 possesses two interchangeable measurement inputs arbitrarily labelled A and B. An input from the reference source (normally a rubidium oscillator or hydrogen maser) at 5 or 10 MHz is connected to A and an input from the device under test (at an identical nominal frequency to the reference input) is connected to B. Both inputs, regardless of their input value, are multiplied using harmonic multipliers to 100 MHz and then mixed down to a 1MHz intermediate frequency using an internal local oscillator at 99 MHz. As the local oscillator is common to both channels, any phase jitters or drift will eventually be removed when the channels are compared, which is extremely important. The local oscillator is phase locked to one of the inputs by comparing the output of a divide by 99 circuit with the 1MHz intermediate frequency. The 1MHz signals are then multiplied to 10 MHz. The 10 MHz from channel B is then converted to 9MHz by mixing with a 1MHz signal derived from the local oscillator. The 10MHz from channel A is mixed with the 9MHz from channel B to give the 1MHz difference. This basic 1 MHz difference signal is then made available at the front panel and further processed as follows. It is filtered by a crystal filter to remove the sidebands from all of the mixing processes and thereby reduce the noise bandwidth. The filtered 1MHz difference signal is mixed down to 100kHz by means of a 900kHz local oscillator obtained by division from the 99MHz local oscillator. This 100kHz signal is then divided by 100000 to give 1Hz pulses, which are output to the front panel.

The frequency multiplier unit may be operated in two different modes: frequency mode and phase/time difference mode. Frequency mode is the most useful for adjustment purposes, as short gate times may be used with sufficient resolution to adjust even a rubidium standard quickly. Frequency mode is also useful for stability analysis of τ less than 1 second, when the phase difference can't be used. The phase/time mode is the best way, however, of acquiring data from the comparison of two very stable sources for later statistical analysis, especially for τ between 1 and 10000 seconds.

Together with the supplied MATHCAD software, the A7 may be used to calculate Allen, Modified Allen, Time and Total Variance of a frequency standard. It is also possible to calculate rms. and max. Time Interval Errors. It will also be possible, when the appropriate routine is fully operational to provide averaged frequency over a selectable averaging time from the phase difference run. What this effectively provides is the mean slope of the phase curve. It is important to remember, however, that the frequency difference may always be obtained by differentiating the time difference with respect to time over a required averaging time.

This all sounds very complex, but in fact the A7 is particularly easy to use. For example to make a measurement in phase/time difference mode the following steps must be followed. The A7 is set to phase/time difference mode and the inputs are applied to A and B. The statistics menu is chosen from virtual front panel-using the VIRT200 software- and the option "Acquire N meas." is selected. A sample size is chosen and "START" is selected. The counter will proceed to acquire N measurements. Due to occasional communication errors it is advisable to run the VIRT200 under DOS. This means that that the keyboard is disabled during data acquisition. At the end of data acquisition either the mean (used to get higher accuracy by averaging many measurements), the standard deviation (to see the amount of noise in the signal or its stability), the min and max. (To show fm deviation, worst case condition or as a debugging tool to detect error conditions or glitches in digital systems), or peak to peak selection (which equals max-min) will be displayed. As mentioned each of the above has it advantages and disadvantages.

The statistics modes are useful for characterising signals or capturing many measurements at high speed. You can view results on the screen, graph the data or save the measurements to a file. The data files are in plain ASCII format. This enables the user to read the data into their individual workstation and perform complex data analysis on the raw data. In today's connected world it is also possible to send such data to remote locations as an attachment or post it on your companies web site.

The A7 has the ability to precisely resolve frequency and time. In doing so, both accuracy is increased and measurement time is reduced. The A7 can determine any frequency to 0.1 part per million in just 1 ms and resolve each time measurement to 100ps. When combined with an acquisition rate of 2300 measurements every second- incidentally one of the fastest rates available- the A7 is capable of acquiring more data per second than a typical GPIB counter can manage in 1 minute. Such fast measurement acquisition and increased accuracy lead to a more thorough analysis of your signal. When you think about it, can you really afford to be without the A7 for much longer ???