

## DEVICE AND METHOD FOR PROVIDING ACCURATE TIME AND/OR FREQUENCY

### RELATED APPLICATION

This application is a File Wrapper Continuation of application Ser. No. 07/471,764 filed on Jan. 29, 1990 entitled "Device and Method For Providing Accurate Time And/Or Frequency", now abandoned.

### FIELD OF THE INVENTION

This invention relates to a device and method for enhancing the accuracy of a unit such as an oscillator and/or clock, and, more particularly, relates to a device and method for providing accurate time and/or frequency.

### BACKGROUND OF THE INVENTION

It is well known that oscillators and/or clocks will, over time, produce outputs having frequency and/or time accuracy errors.

Any two independent clocks, for example, once synchronized, will walk away from one another without bound, and the difference between them will exceed any limit given enough elapsed time. Improvements in the performance of a clock unit may slow this process but will not eliminate it.

One method for maintaining agreement between two clock (or oscillator) units involves a continuous, or nearly continuous, communication between them. This is inconvenient and impractical in general, and most clocks, for example, are periodically reset (using correct time from an external reference) to maintain synchronism. Although the two clock units agree each time the reset is performed, the clock readings walk away from one another between resets.

Some systems attempt to correct for clock error, for example, by using an estimate of the clock rate difference. None of the heretofore known methods of either periodic clock reset or the use of static rate offset, however, optimally utilize the information available to construct a statistically robust model of the performance of the actual clock in its environment and they are therefore much less efficient than they could be.

Errors due to time offset, frequency offset, frequency drift, clock noise and external perturbations all contribute to inaccuracies of an oscillator/clock unit output between calibrations, or updates, and existing processes provide no means for assessing the accuracy of output readings during these intervals.

### SUMMARY OF THE INVENTION

This invention provides a device and method for providing an accuracy enhanced unit output based upon utilization of established predictions of output variations, which predictions are updated based upon a reference. Where the unit is an oscillator and/or clock, the reference may be indicative of correct frequency and/or time, with the reference being preferably supplied from an external source, or standard. Updating of the variation predictions may be carried out as needed for a particular purpose, and normally can be more infrequent as the predictions of output variations improve.

For a frequency and/or time accuracy enhanced unit, the device preferably includes an oscillator/clock unit the output of which is continuously monitored and controlled by a processor section, which processor section preferably includes a microprocessor. The mi-

croprocessor may be utilized to supply corrections to the oscillator/clock unit, or a separate microprocessor-controlled correction unit, such as a servo system, may be utilized.

In addition, the microprocessor may be utilized to compare the oscillator/clock unit output to a reference for updating predictions, or a separate microprocessor-controlled comparison system may be utilized. The comparisons against the reference (an external standard) are used to develop measures of performance of the internal oscillator/clock unit, to provide information to the continuous correction unit and to provide a continuous statistically robust estimate of the errors of the device.

It is therefore an object of this invention to provide an improved device and method for enhancing the accuracy of the output of a unit.

It is another object of this invention to provide an improved device and method for enhancing the accuracy of a unit output by establishing and using predicted variations based upon past performance of the unit.

It is still another object of this invention to provide an improved device and method for enhancing the accuracy of a unit output by establishing and using predicted variations based upon past performance of the unit and updating the predicted variations utilizing comparisons between the unit output and an external reference.

It is still another object of this invention to provide an improved device and method for accurately generating time and/or frequency using predicted variations based upon the past performance of an oscillator/clock unit and updating the predicted variations utilizing comparisons between the output of the oscillator/clock unit and a correct reference indicative of the correct frequency/time.

It is still another object of this invention to provide an improved device and method for enhancing the accuracy of the output of a unit wherein only infrequent reference to an external standard is required.

It is still another object of this invention to provide an improved device and method for enhancing the accuracy of the output of a unit by providing a continuous statistically robust estimate of unit errors derived from the calibration history and an internally constructed model.

With these and other objects in view, as the description proceeds, it will become apparent to one skilled in the art that this invention resides in the novel construction, combination, arrangement of parts and method substantially as hereinafter described, and more particularly defined by the appended claims, it being understood that changes in the precise embodiment of the herein disclosed invention are meant to be included as come within the scope of the claims.

### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate a complete embodiment of the invention according to the best mode so far devised for practical application of the principles thereof, and in which:

FIG. 1 is a graph illustrating time and frequency (slope of the curve) accuracy, or error, of a typical quartz-crystal oscillator/clock unit;

FIG. 2 is a block diagram illustrating an example of the device of this invention;