SIGNAL RECOVERY

Input Offset Reduction using the model 7265/7260/7225/7220 Synchronous Oscillator/ Demodulator Monitor Output

APPLICATION NOTE

AN 1001

Introduction

The ***SIGNAL RECOVERY*** (formerly EG&G/PerkinElmer) models 7220, 7225, 7260 and 7265 Digital Signal Processing (DSP) lock-in amplifiers, when used in the external reference mode, are able to generate a sinusoidal signal of variable amplitude and variable phase with respect to the applied reference. This signal can be used to null out the "steady state" value of signals at their inputs, allowing small signal changes to be more easily measured.

This input offset suppression is useful in such applications as Hall effect studies where it offers better performance than the output offset capability also available in the instruments.

In the models 7260 and 7265, the term Synchronous Oscillator is used to describe this feature, but in the models 7220 and 7225 it is known as the Demodulator Monitor. In order to avoid confusion, throughout the rest of this Technical Note the former term will be used.

Synchronous Oscillator Operation

The operation of the Synchronous Oscillator is best understood by reference to the simple block-diagram of part of a lock-in amplifier, shown in figure 1.

The diagram shows the signal and reference channels, and the in-phase mixer, or phase-sensitive detector (PSD) found in the models 7220, 7225 7260 and 7265 dual phase lock-in amplifiers. The quadrature mixer has been omitted for the sake of clarity.

When the synchronous oscillator output is activated, the output at the **OSC OUT** connector on the front panel becomes an analog representation of the sinusoidal drive signal to the in-phase PSD, rather than simply the internal oscillator output. Its amplitude can still be controlled, using the oscillator's level control, to voltages between 1 mV and 5.000 V, but its frequency is now set by the external reference frequency input signal. In addition, its phase relative to the applied phase-shifter can be adjusted in 10 m° increments using the instrument's reference phase-shifter.

Note that due to a lack of sufficient connectors on the instrument, it is not possible to make both the oscillator output and the synchronous oscillator output available simultaneously. Hence the technique cannot be used for input offset reduction when using internally referenced experiments and so the synchronous oscillator output is not available when the instrument is set to internal reference mode.

Operation is generally easier if the instrument is set to R-θ (vector magnitude and phase) display mode, although it is still possible to use the technique in the X-Y display mode.

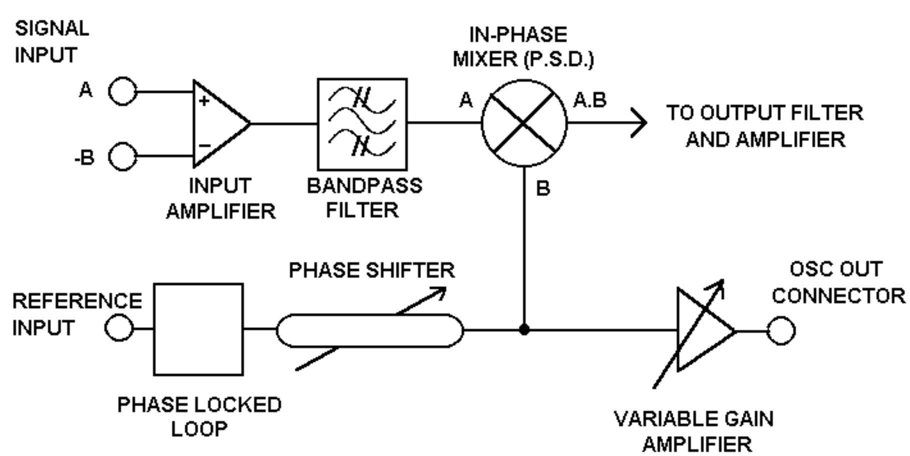

Figure 1

Offsetting a Voltage Signal

In order to use the input offset reduction technique, it is necessary to couple the synchronous oscillator output signal back to the instrument's input. There are various ways in which this can be done, and two of these are shown in figures 2 and 3.

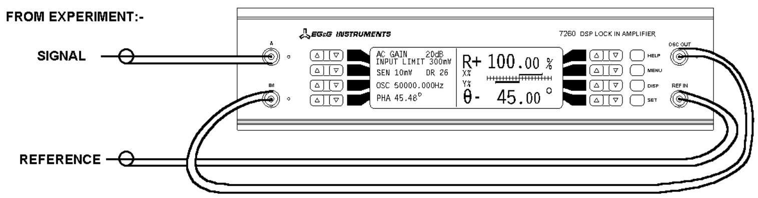

Figure 2
Connecting the Synchronous Oscillator Signal using the 7260 Differential Input Amplifier

Figure 2 shows the easiest way to make the required connections and is suitable for use when the signal to be measured is a single-ended voltage. The instrument controls are then set as follows:-

a) Perform an auto-default operation to set the instrument to a defined state. This operation automatically sets the outputs to R-θ mode.

b) Set the unit to external reference mode and connect the reference signal to the selected input, either **REF IN** on the front panel or **TTL REF IN** on the rear panel. Connect the signal to the **A** input connector and connect a cable between the **OSC OUT** connector and the **B/I** connector.

c) Adjust the experiment so that the measured signal is at the level that it is required to be offset to zero, i.e. establish the "steady" state value from which changes will be measured.

d) Perform an auto-sensitivity function.

e) Perform an auto-phase function. The result of steps d) and e) will be to set the instrument so that the signal at the reference input to the X-channel PSD is in phase with that at the signal input.

f) Note the measured signal magnitude. In order to offset this signal, the synchronous oscillator amplitude needs to be set to exactly the same level. Since the synchronous oscillator output can only be adjusted between 1 mV and 5 V, it may be necessary to use of a coaxial attenuator inserted in the BNC cable between the **OSC OUT** and **B** connectors in order to obtain the correct level.

In addition, the resolution with which the amplitude can be adjusted is better at larger output amplitudes. For example, with no attenuator and if the measured signal were 800 mV then the oscillator amplitude control provides sufficient resolution, but if the signal level were 2 mV then it will not. However, if a ×1000 attenuator (60 dB) is fitted then the oscillator amplitude control will provide microvolt resolution, which is sufficient.

g) Set the oscillator amplitude control so that the amplitude following the attenuator, if fitted, is the same as the measured signal.

h) Turn the synchronous oscillator output on and set the signal input mode to differential (A-B) mode. This will cause the input to the signal channel to become equal to the input signal minus the synchronous oscillator output level. Since these two signals are nominally equal, the displayed magnitude will decrease.

i) Use the instrument's reference phase control to obtain a minimum output. Do not try to use the auto-phase function since it will not work correctly when using the instrument in this mode.

j) Make fine adjustments to the oscillator amplitude and reference phase controls to further reduce the output. It should also be possible to increase the full-scale sensitivity range.

k) The system is now set up to measure small changes in the applied signal. Because the offset level has been removed by the above procedure, the full input dynamic range is available for the measurement, giving the best possible accuracy.

Offsetting a Current Signal

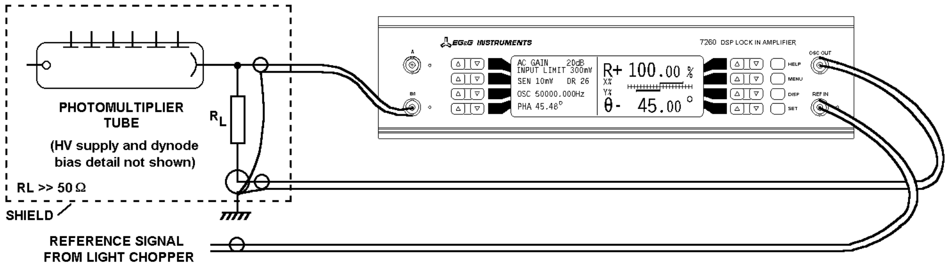

Figure 3
Connecting the Synchronous Oscillator Signal using an External Resistor

Figure 3 shows the use of the technique when measuring a current signal, such as that from a photomultiplier tube. The resistor R_L injects an offset current, derived from the synchronous oscillator output, into the lock-in amplifier's current input. It needs to be chosen in a similar way to that described above for choosing an attenuator so that the injected current equals the offset level to be removed.

The controls are adjusted in a similar way as described for the first example, except that because the injected current is now in phase with the signal to be measured, the reference phase control needs to be adjusted to bring the signal and reference inputs to the in-phase PSD to be 180° out of phase. This causes the synchronous oscillator output, and hence the injected current, to also be 180° out of phase with the signal as is required for offset reduction.

The overall procedure to adopt is therefore:

a) Perform an auto-default operation to set the instrument to a defined state. This operation automatically sets the outputs to R-θ mode.

b) Set the unit to external reference mode and connect the reference signal to the selected input, either **REF IN** on the front panel or **TTL REF IN** on the rear panel.

c) Set the signal channel input to current mode and connect the signal input to the B/I input connector. At this stage there should be no connection to the input of the current injection resistor, R_L

d) Adjust the experiment so that the measured signal is at the level that it is required to be offset to zero, i.e. establish the "steady" state value from which changes will be measured.

e) Perform an auto-sensitivity function.

f) Perform an auto-phase function. The result of steps e) and f) will be to set the instrument so that the signal at the reference input to the X-channel PSD is in phase with that at the signal input.

g) Change the reference phase shift control by 180°. This is done most easily by pressing either the +/-90° key on the 7260 or 7265's Reference Menu, or the 90° key on the 7220 or 7225's front panel, twice.

h) Note the measured signal magnitude. In order to offset this signal, the injected current given by the synchronous oscillator amplitude and the injection resistor, R_L, needs to be set to exactly the same level. Since the synchronous oscillator output can only be adjusted between 1 mV and 5 V, it may be necessary to use a coaxial attenuator inserted in the BNC cable between the **OSC OUT** and injection resistor connectors in order to obtain the correct level.

   In addition, the resolution with which the amplitude can be adjusted is better at larger output amplitudes. For example, with no attenuator and if the measured signal were 800 mV then the oscillator amplitude control provides sufficient resolution, but if the signal level were 2 mV then it will not. However, if a ×1000 attenuator (60 dB) is fitted then the oscillator amplitude control will provide microvolt resolution, which is sufficient.

i) Set the oscillator amplitude control so that injected current given by the amplitude following the attenuator, if fitted, and the injection resistor, R_L, is the same as the measured signal.

j) Turn the synchronous oscillator output on and connect a cable, and the attenuator if used, between the **OSC OUT** connector and the injection resistor connector.

   This will cause the input to the signal channel to become equal to the input signal minus the synchronous oscillator output level. Since these two signals are nominally equal, the displayed magnitude will decrease.

k) Use the instrument's reference phase control to obtain a minimum output. Do not try to use the auto-phase function since it will not work correctly when using the instrument in this mode.

l) Make fine adjustments to the oscillator amplitude and reference phase controls to further reduce the output. It should also be possible to increase the full-scale sensitivity range.

m) The system is now set up to measure small changes in the applied signal. Because the offset level has been removed by the above procedure, the full input dynamic range is available for the measurement, giving the best possible accuracy.

Conclusion

The use of the Synchronous Oscillator output, believed to be unique to the ***SIGNAL RECOVERY*** models 7220, 7225, 7260 and 7265, for input offset reduction is invaluable for those experiments where small changes in large signals must be measured. Although it is a little more complex to use than the output offset controls, which are also provided on these instruments, it offers better performance because the full dynamic range of the instrument is available for the measurement.

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