SIGNAL RECOVERY

Dual-Channel Absorption Measurement with Source Intensity Compensation

APPLICATION NOTE
AN 1000

Introduction

The **SIGNAL RECOVERY** (formerly EG&G/PerkinElmer) models 7260, 7265 and 7280 Dual Phase DSP Lock-in Amplifiers include a dual reference mode which allows the independent, but simultaneous, measurement of two signals of different frequencies. One application for which this mode is ideally suited is the removal of errors due to source intensity fluctuations in optical measurements.

The few restrictions which are imposed by the use of the dual reference mode, such as a normal maximum operating frequency of 20 kHz, do not usually cause any problems in this type of experiment. This is because the signals to be detected are caused by chopped light beams, typically generated by mechanical rotating-blade light choppers, and hence the maximum frequencies encountered are only a few kilohertz.

Problem

A customer wished to measure simultaneously the optical absorption of a sample at two wavelengths, namely 410 nm and 405 nm. However the available light sources at these wavelengths were not stable enough to use without compensation for their intensity fluctuations, and so the system as shown in figure 1 was utilized.

Description of Solution

The outputs of the two hollow-cathode lamps are combined, using a dichroic beam combiner, to form a single beam containing both 405 and 410 nm. This beam strikes a second dichroic beam combiner/splitter, and is split so that it passes via the reference and sample paths. The reference beam passes via the first of two light choppers, which is running at 210 Hz, and is then reflected back via the reference mirror. The sample beam passes through the sample chamber, is chopped by the second light chopper at 294 Hz, reflected back via the sample mirror and makes a second pass through the sample chamber.

Both sample and reference beams are recombined at the beam combiner and pass to a monochromator which is equipped with two exit slits adjusted to 410 nm and 405 nm center wavelengths. Each slit is fitted with a photomultiplier tube (PMT) detector, shown as PMT1 and PMT2 in the diagram.

Hence the electrical signal generated by PMT1 has a component at 210 Hz, resulting from that part of the output from the 410 nm lamp which passed via the reference mirror, and a component at 294 Hz, resulting from that part which passed via the sample chamber and mirror. In a

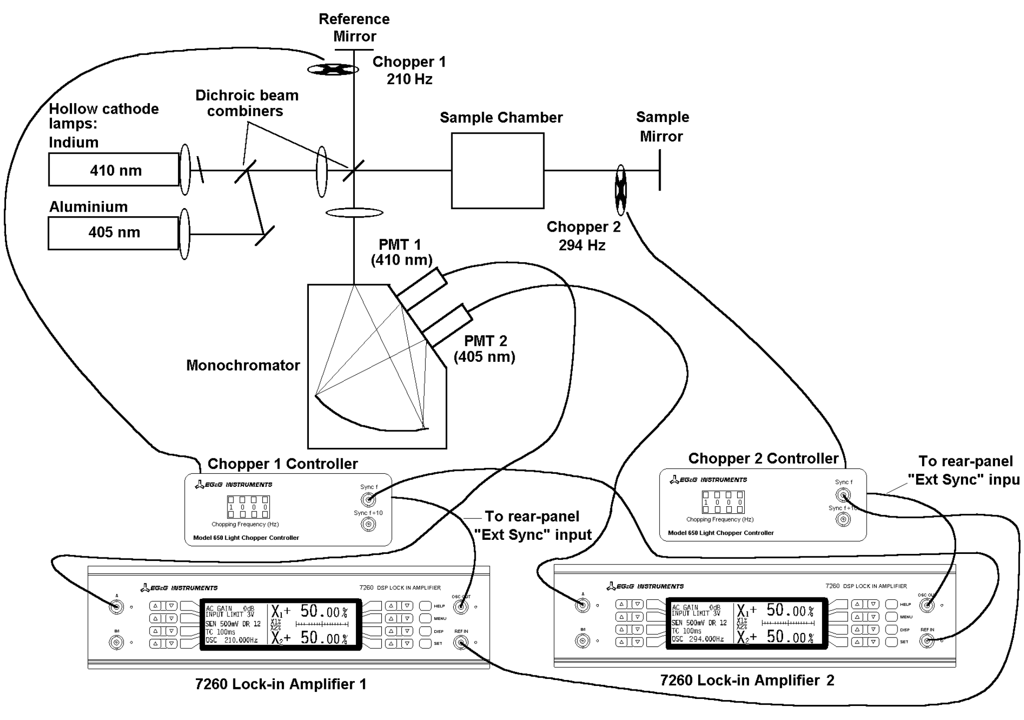

Figure 1

similar way, the signal at the output of PMT2 has a component at 210 Hz, resulting from that part of the output of the 405 nm lamp which passed via the reference mirror, and a component at 294 Hz, resulting from that part which passed via the sample chamber and mirror.

Two model 7260 lock-in amplifiers, both operating in dual reference mode, are used to detect these signals with the connections made, and controls set, as follows:-

1) The first instrument's internal oscillator is set to 210 Hz and a cable is connected between its **OSC OUT** connector and the external sync input of the chopper 1 controller.
2) The switch on the rear panel of the chopper 1 controller is set to external sync mode, and so the chopper 1 frequency is also 210 Hz.
3) The SYNC output of chopper 1, which is therefore also at 210 Hz, is connected to the **REF IN** reference input connector on the front panel of the second 7260 lock-in amplifier.
4) This second 7260's oscillator is set to 294 Hz and, in the same way as for the first unit, a cable is connected between its **OSC OUT** connector and the external sync input of the second chopper (chopper 2) controller.
5) The switch on the rear panel of the chopper 2 controller is also set to external sync mode, and so the chopper 2 frequency is also 294 Hz.
6) Finally, the loop is completed by a cable linking the **SYNC** output of chopper 2, which is therefore also at 294 Hz, to the **REF IN** reference input connector on the front panel of the first 7260 lock-in amplifier.

Hence the first lock-in amplifier runs at an internal reference frequency of 210 Hz and an external reference frequency of 294 Hz, whilst the second runs at an internal reference frequency of 294 Hz and an external reference frequency of 210 Hz. The signal inputs of the two instruments are connected to PMT1 and PMT2 respectively.

When all four reference phases are adjusted for maximum X-outputs, the following outputs are generated:

Lock-in amplifier 1:-

- X1 output corresponding to the 410 nm, 294 Hz signal at PMT1 which passed through the sample
- X2 output corresponding to the 410 nm, 210 Hz signal at PMT1 which passed through the optical reference path.

Lock-in amplifier 2:-

- X1 output corresponding to the 405 nm, 210 Hz signal at PMT2 which passed through the optical reference path.
- X2 output corresponding to the 405 nm, 294 Hz optical at PMT2 which passed through the sample

These four outputs are transferred to a computer via each of the instruments' RS232 interfaces using the compound command X1;X2 which reports the present value of the X1 and X2 outputs respectively.

Any change in the absorption of the sample in the sample chamber affects only the intensity of the 294 Hz signals at PMT1 and PMT2, whereas any change in the intensity of the hollow cathode lamps affects the signals at both 294 Hz and 210 Hz. Hence by calculating the ratio X1/X2 of the outputs of lock-in amplifier 1, and X2/X1 of the outputs of lock-in amplifier 2, the effect of these fluctuations can be removed and the absorption measured at each wavelength independently.

The calculations are performed by a user-written program running on a controlling computer (not shown in figure 1) which operates both instruments via their RS232 interface(s).

Conclusion

The combination of the unique dual reference mode provided by the models 7260, 7265 and 7280 and a simple optical design for the experiment allows two independent source-compensated optical absorption measurements to be made using only two lock-in amplifiers. Traditional approaches to the same experiment would require four instruments. In addition to this saving in equipment, the dual reference mode provides more accurate measurements since both the signal and reference are detected by the same detector and follow the same signal path, thereby avoiding problems caused by differential drift between two different detectors and instruments.

Acknowledgement

SIGNAL RECOVERY acknowledges the assistance of Dr P Brewer of Hughes Research Laboratories, Malibu, California, USA, in the preparation of this applications note.

SIGNAL RECOVERY

SIGNAL RECOVERY is part of **AMETEK** Advanced Measurement Technology, Inc

801 SOUTH ILLINOIS AVENUE
OAK RIDGE
TN 37831-2011
USA
Phone: +1 865 482 4411
Fax: +1 865 483 0396

SPECTRUM HOUSE
1 MILLARS BUSINESS CENTRE, FISHPONDS CLOSE
WOKINGHAM, BERKS RG41 2TZ
UNITED KINGDOM
Phone: +44 (0)118 936 1210
Fax: +44 (0)118 936 1211

E-mail: info@signalrecovery.com **Web Site: www.signalrecovery.com**