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Note

Rapid square wave interference on high-performance liquid chromatographic output caused by a digital display

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As the technique of high-performance liquid chromatography (HPLC) increases in popularity, investigators require greater sensitivity from their instruments. For this reason, we have been using a Laboratory Data Control HPLC system (LDC, Stone, Great Britain) for over two years to measure levels of the cytotoxic drug melphalan in plasma samples from patients[1]. As melphalan absorbs maximally around 260 nm, greatest sensitivity was obtained by using a fixed-wavelength UV III monitor at 254 nm. This has a theoretical maximum noise (peak to peak) of less than 0.00002 a.u. which, with our extraction system, gives a limit of sensitivity of approximately 5 ng melphalan per ml of plasma[2].

It was with some consternation, therefore, that having purchased a second identical HPLC system, a randomly occurring, but very specific type of noise of up to 0.0001 a.u. sometimes appeared which could generate a baseline 10 mm wide.

THE PROBLEM

The problem is illustrated in Fig. 1. Fig. 1a shows a typical trace on slow chart speed and Fig. 1b shows the same noise on the maximum chart speed of 4 mm/sec. It was always a well defined transition from the initial line to another one where the transition could be randomly either positive or negative. Periods of these transitions would occur for short times or for up to 3 h at any time of day or night, and each transition seemed to be randomly timed within these periods. The frequency of the transitions or square waves was very variable and could be very rapid.

POSSIBLE CAUSES

The recorder was quickly eliminated as the cause of the noise, and various possible sources in the monitor such as UV bulb and flow cell were ruled out by

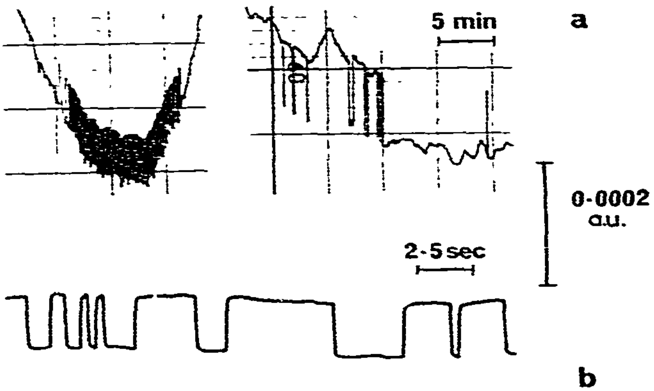

Fig. 1. Typical traces of the interference at (a) low and (b) high chart speed showing the square-wave formation.

swapping components. The manufacturers were called in, but on taking the monitor back to Stone, the fault could not be reproduced (at that time no-one knew how to induce it) and so the local 240 V mains was suspected.

An isolating transformer and an extra mains filter were incorporated with no apparent success. The mains was monitored and the hospital site searched for the possibility of electric welding or interference from other sources such as heating ovens or freezers. The latter were known to cause spikes on the baseline, but never caused the pen to change from one position to another. Badly wired three-pin plugs were also found and suspected. Possibly induced interference in the lead connecting the monitor to the recorder was also ruled out by installing a shielded cable.

Although a couple of the possible causes, when corrected, seemed to cure the fault, it always reappeared at a later date.

THE SOLUTION

Perusal of the block diagram of the circuits of the monitor suggested that the digital display could have an effect on the recorder output under various conditions and, sure enough, the cause of the interference was immediately observable! It was obvious that almost every time a digit on the display changed, the pen would change position. The magnitude and direction of this change depended on which digit change was taking place. Fig. 2 shows the display digits and the hop sizes in "quantum" units. Each "quantum" was about 0.00002 a.u. (or 100 μV on 0.002 a.u.f.s.) and was caused by a segment of the 7-segment display being switched on or off.

The problem suggested bad power regulation in the power supply unit, but this was found not to be the case when a new power supply board did not solve the problem.

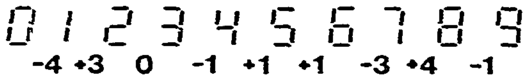

Fig. 2. Digital display digits showing the "quantum" jumps associated with each change.

Eventually, it was found that the problem was due to the fact that the common lead from the LED display module was connected to the common point of the signal processor board (and other boards) which in turn was connected to the power supply common. As the leads involved were relatively long in length the resistance was obviously significant and the extra current drawn by the LEDs caused the earth or common point to float up or down (by simple Ohm's law). Admittedly it is a very small change (*ca.* 100 μV) but enough to cause the problem delineated.

The problem was solved by rerouting the common of the LED display directly to the common point of the power supply module, hence ensuring that the common lead to the rest of the circuit was more stable.

Note to those with similar problems

This problem is only likely to have occurred on LDC UV III monitors installed in 1981. Before contacting the manufacturers, confirm categorically that the interference is of this type and not any of the many possible sources of user-caused interference[3] —the details outlined in this note should be very diagnostic. If this particular problem is proven, then it is advised that the manufacturers make the alteration so that no warranty is voided.

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