SPIRE Technical Note

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Implications of reduced SMEC scan speed range

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Introduction

The design of the MCU has been changed to remove the “zero crossing” detection circuit which allows fast count of encoder steps within the analogue electronics. This in turn means that the fastest controlled speed of the SMEC will be 1 mm/s rather than the 5 mm/s that would have been achievable with the zero crossing detection. Whilst this is fully compatible with the requirement, it does limit the speed of the flyback if unidirectional scanning is employed. It will therefore impact on the requirement for no more than 10% dead time in the acquisition of useful data with the spectrometer.

In this note I look at the implications of this decision for the spectrometer operations, in particular I look at the implementation of forward and reverse scanning and the possibility of having uncontrolled flyback of the SMEC followed by “finding” itself again. This note represents the disposition of HR-SP-LAM-ECR-001.

Present Assumption

There is no explicit definition the method of operating the SMEC in the specification document. In principle if the 5 mm/s speed were available unidirectional scanning could be implemented as shown in figure 1. However, even here, the 10% dead time requirement will not be met under nominal operating conditions (i.e. scanning at 0.5 mm/s) because time has to be allowed for the mechanism to slow down and speed up again. Whatever time is required for this, because the scan time on the flyback is already = $T_{scan}/10$, the dead time requirement must be violated.

The dead time requirement can be met for forward and reverse scanning – i.e. taking data on the reverse portion of the scan as shown in figure 2. Here only the time required for deceleration and acceleration is dead time and we can assume that for all but the shortest scans this will be $<T_{scan}/10$. For the nominal resolution of 0.4 cm^{-1} the scan time will be ~13 s, therefore the deceleration and acceleration must be completed in <1.3 s. This does not seem onerous. For low resolution, say 2 cm^{-1}, the scan time will be ~2.5-3 seconds and here the dead time requirement (~250 millisecs) will very likely be exceeded under all circumstances.

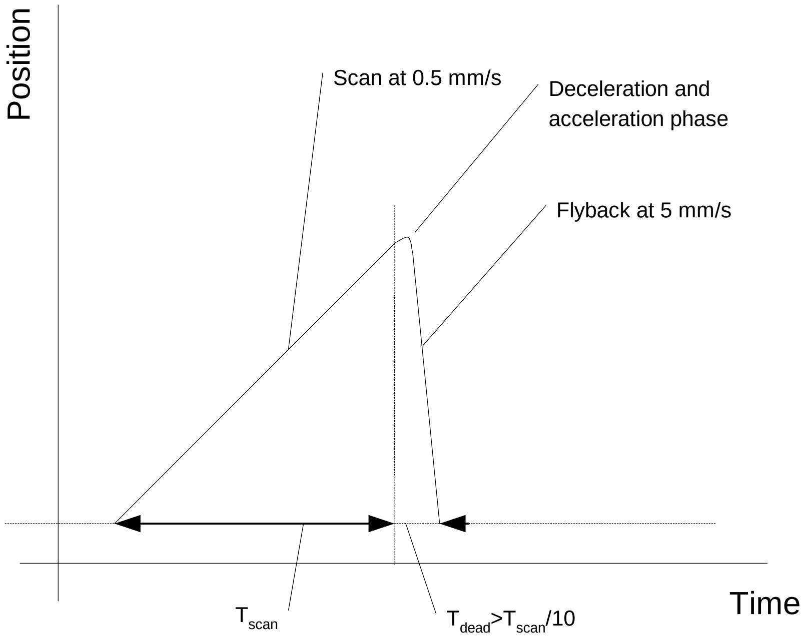

Figure 1: Position versus time profile for uni-directional scanning showing definition of scan time and dead time.

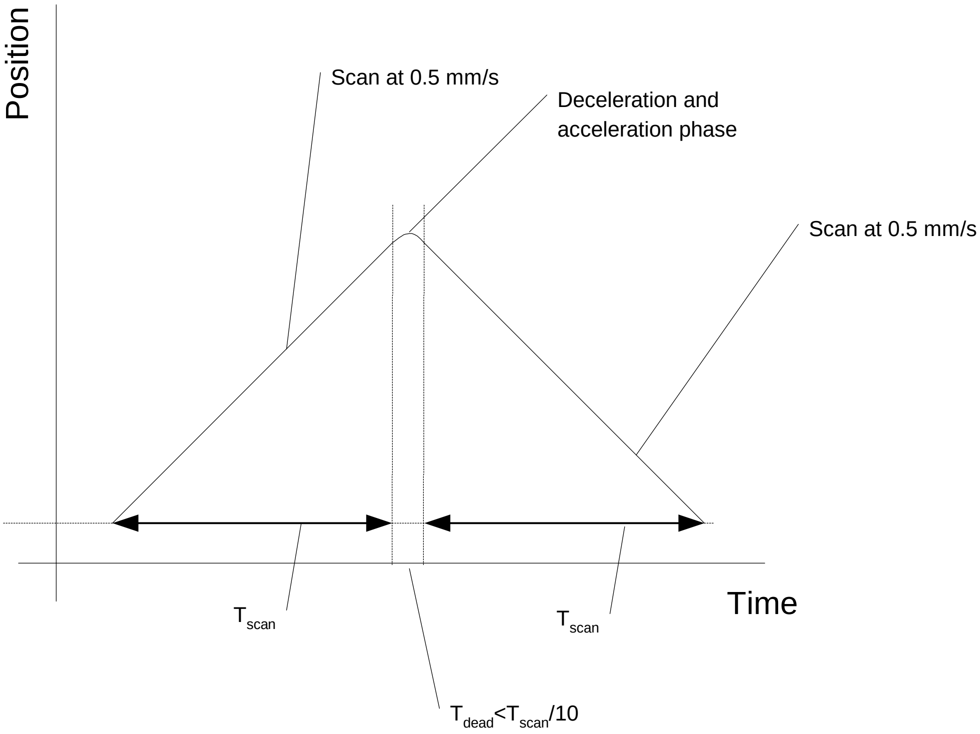

Figure 2: Position versus time profile for bi-directional scanning showing definition of scan time and dead time.

New Situation
The removal of the analogue zero crossing circuit restricts the ability of the SMEC to scan *and not lose steps* at a maximum speed of 1 mm/s. The italics are important here – LAM should confirm that the SMEC can be moved faster than 1 mm/s but that there is a high likelihood that the mechanism/electronics will get “lost”. If this is the case (and for the sake of argument I will assume it is) then we may still be able to institute moderately efficient uni-directional scanning.

In any case the default scan mode should now be assumed to be forward and reverse scanning and, apart from the low resolution operation, the 10% dead time requirement can be met. The dead time requirement should be relaxed for low resolution operation – LAM should advise what minimum time is required for the SMEC to turn around from 0.5 mm/s in one direction to 0.5 mm/s in the other direction. This should be set as the requirement.

If we can have “uncontrolled” rapid scanning then we could envisage a uni-directional scan mode as shown in figure 3. Here we assume that the SMEC ends the flyback without “knowing” where it is with any precision and the flyback scan is carried out using a coarse speed measurement and an elapsed time. Once the SMEC stops at the end of the flyback, the electronics can know that the position is within the LVDT and will know the actual position to within the precision given by the LVDT. A “find home” command can then be executed to recalibrate the steps in the encoder, the SMEC moved to the start position for the scan and the next scan started. Whist this last process may take a little time, the whole deceleration; acceleration; flyback and find itself procedure should take less time than using the fastest controlled speed on the flay back. If it is possible to implement this method of operation then it is highly desirable that it is available as there may be unanticipated problems in only having bi-directional scanning available. If this method of scanning is available then the requirement for 10% dead time will not apply.

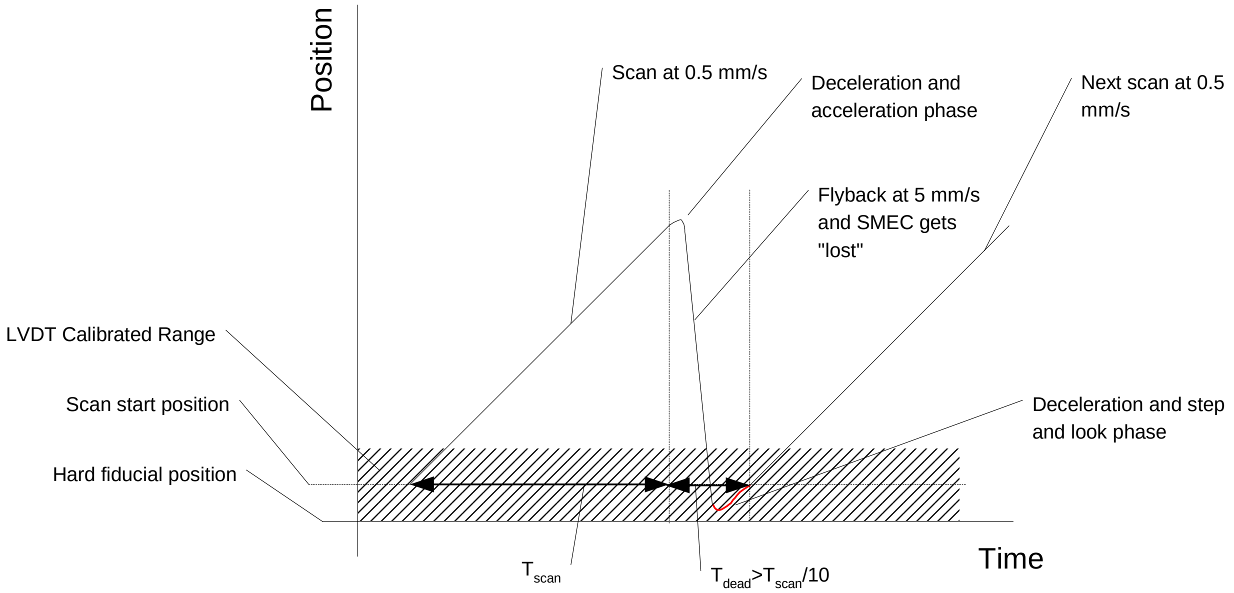

Figure 3: Possible method on implementing uni-directional scanning assuming loss of position during flyback.

Simulation of Bi-Directional Scanning

To test whether there would be any major problems inherent in taking data using bi-directional scanning, I ran the FTS simulator I have described before with alternate scans taken in “forward” and “reverse” directions. Figure 4 shows the simulated change in OPD and figure 5 shows the time series of the simulated detector response. In figure 6 I show a close up of the simulated detector response around ZPD with the forward and reverse scan data coloured separately. A change in phase is evident (not unexpectedly) between the forward and reverse scan directions. A phase change such as this, if seen as clearly as this, will be relatively easy to remove. However, the show the effect in the spectral domain I transformed the forward and reverse data without fixing anything. The results are shown in figures 8 and (close up) 9. A shift in the line frequency appears to be the result – again the result here is clear and would be easy to correct with suitable calibration.

So there appears to be no major problem inherent in bi-directional scanning, however a problem could occur if there were undetected hysteresis in the system at large travel as phase errors here would be difficult to detect if the lines were faint. We would therefore be prudent to retain the ability to have uni-directional scanning in as an efficient manner as possible.

Conclusions

i) Removal of the analogue zero crossing detection circuit and subsequent reduction in controlled speed range is acceptable
ii) Bi-directional scanning is now the default mode of operation
iii) Uni-directional scanning with uncontrolled high speed flyback followed by re-calibration of position should be investigated as a possible alternative operating mode
iv) The dead time requirement should be changed from a percentage to a fixed overhead time for deceleration and acceleration from each of the selectable scan speeds. LAM should advise on what these times should be and the requirement will be updated accordingly

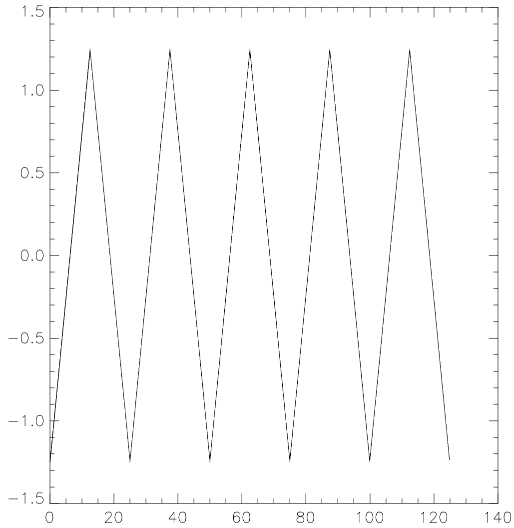

Figure 4: Simulated OPD versus time from the IDL program.

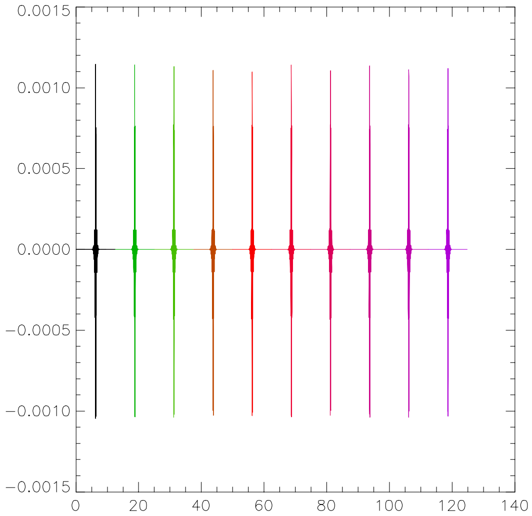

Figure 5: Simulated detector response versus time from the IDL program. Each scan coloured separately

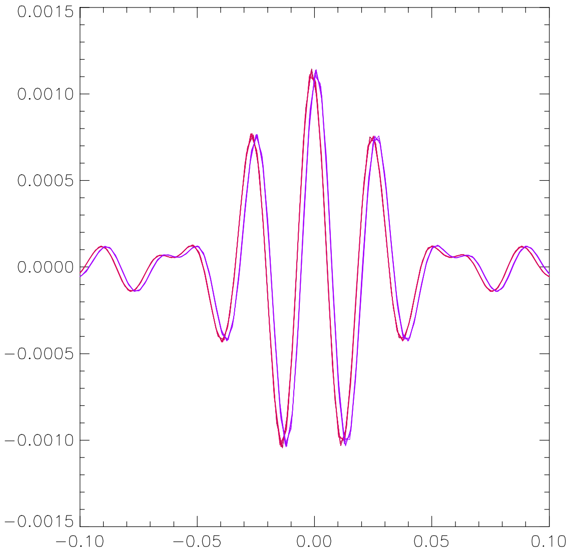

Figure 6: Close up of simulated detector response in OPD region around ZPD for “forward” (purple) and “reverse” (red) scan directions

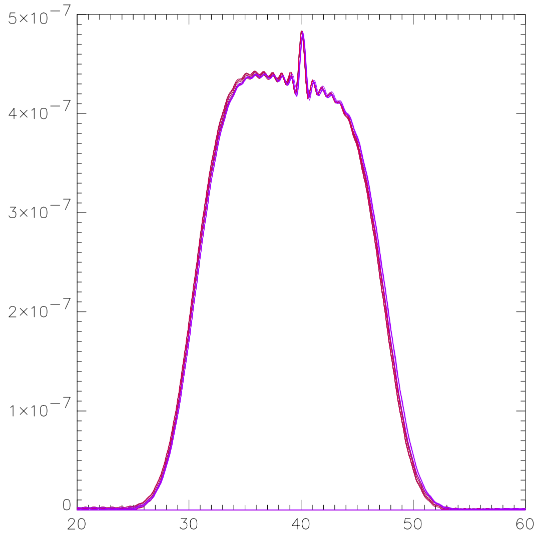

Figure 7: Data from figure 6 transformed to spectral domain showing forward and reverse scans as purple and red.

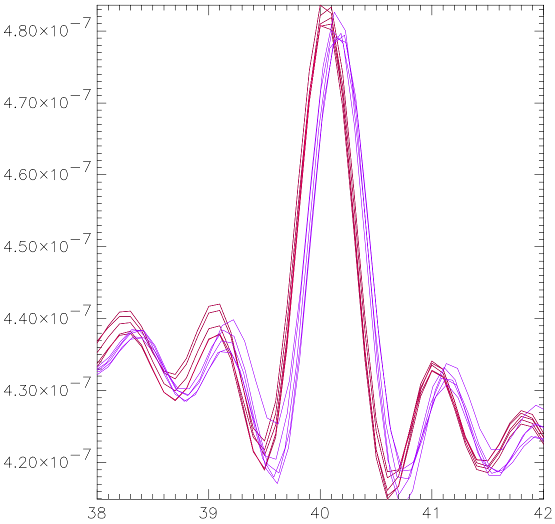

Figure 8: Close up of data in figure 7 around emission line.