AcqNmr: Basic and Mute data accumulation modes

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I. Introduction

The new mode-selection parameter **DAAM** (Data Acquisition and Accumulation Mode) introduces the topic of distinct data acquisition modes. At present it admits two possibilities:

BASIC is the mode used up to now.
MUTE is a new mode which suppresses monitoring of data during acquisition, (except for the scans counter which remains active).

In both cases, the numeric parameter **DAAP** (Data Acquisition and Accumulation Parameter) is used to control the rate at which the PC checks the progress of acquisition. Its value is in milliseconds and its recommended default is 200 (allowed range is 10 to 2000).

The difference between the two modes lies in different timing when scans need to be repeated very fast and/or the data blocks are large. To understand their effect, we need first to define the following symbols:

BS *Block size* (the parameter appearing in the parameter tables)
BST *Block sequence time*, including the recycle delay (RD), the preparatory pulse sequence and the data acquisition sweep. It is the minimum block time required by NMR only.
SCD *Software cycle duration* is the time the AQM CPU needs to process single-block data. It depends on BS but not on the pulse sequence timing.
SOT *Software overhead time* is the amount of extra time taken up by the processing. Since part of SCD proceeds in parallel with new data acquisition, SOT < SCD.
BTIM *Block duration time* is the actual time needed before restarting a next one.

II. BASIC mode

A. When the theoretical time interval between successive scans (repetition time) is larger than the software overhead related to accumulation and/or display-data transfer to PC, the time lost due to data processing is quite small since most of it is done in parallel with pulser & sweeper actions. The actual delay due to software is in this case roughly 18 ms per 1K of complex data points which is the time needed for a plain transfer of data from the ADC buffers to a core-CPU AQM memory buffer (the flash buffer).

B. Since the full BASIC-mode processing cycle takes about 57+BS*118 ms, with BS being the block size, things look different when the net repetition rate RT_{net} is smaller than this value. The processing then can not be completed in parallel and ends up delaying consecutive scan starts.

Explicitly, the formulae for the *software accumulation overhead* (Sot) are:
Case A) Sot = BS*18, when $RT_{th} \geq$ BS*157,
Case B) Sot = BS*175 -RT_{net} otherwise,
where RT_{net} is the net repetition time one would have if there were no software overhead (I.e., the net pulse sequence duration).

In case A, the parameter **DAAP** has no perceivable effect on overall acquisition timing. Somewhat surprisingly, however, its effect is relatively modest also in case B. The reason is that of the 175 ms of processing, BS*18 are taken up by the flash buffer transfer, about BS*50 by data accumulation, BS*50 by refreshing a "scope image" on the AQM, and 57 by the actual transfer of the image data to the PC[1]. However, since the transfer to PC is asynchronous and has low priority, not all blocks get transferred. If the acquisition is fast, several acquisition scans may occur in each display refresh cycle and, in this case, only

[1] The speed of the PC is almost irrelevant in this context since it is determined by the speed of the AQM.

the latest data are transferred and displayed. The maximum *average* overhead therefore lies between about 118 and 175 ms/Kpoints and its variation with DAAP is relatively small.

In FFC one normally uses small block sizes. For example, with a block size of 64 points, the minimum overhead is about 18*(64/1024) = 1.125 ms/block, while the maximum is about 160*(64/1024) =10 ms/block. Since the recycling delay, polarization and relaxation intervals and field switching times normally take up longer, all processing (except for the flash buffer transfer) is done in parallel and all the software overhead we have is just a bit over 1ms per block.

In classical NMR, however, situations may arise (not very often) when most of the time shall be spent in data processing by the AQM. In such cases the new AQM appears about 30-40% slower than the old one. These are the situations when to use the MUTE mode.

III. MUTE mode

In this mode, the "scope image" on the AQM is not maintained and no graphic data are communicated to the PC during acquisition. The User sees a blank screen and just the scan counter goes on at the rate given by DAAP. Once the accumulation has stopped, however, all the data are transferred to the PC and displayed on the "scope".

This corresponds exactly to what we had with the old system. However, the maximum processing overhead is now only about 60 ms/1points - twice as fast as with the old device.

Moreover, due to the parallelism, it becomes effective only when the theoretical repetition time is lower than 60 ms - for larger repetition times the contribution is only 18 ms/1Kpoints.

This is the absolute minimum for the AQM board - and it has nothing to do with AQM to PC communication.

IV. Practical recommendations

One does not need any particular speed while working "manually" - setting up parameters, checking on things, etc. It is only needed in long accumulations and/or in automations.

So prepare your acquisition using the BASIC mode and, if you need to go at maximum speed, switch to the MUTE mode only before launching the automated acquisition.

If what you plan is an acquisition controlled by a macro and generating lots of data zones, you can always write the macro in a way to display the data of the preceding zone while a new one is being acquired. Alternatively, if monitoring the input is what you want, you can always hook up a classical scope to the analog inputs.