Notes on the QIBA Protocol for Siemens Machines (7/1/09)

I prefer to acquire at least 16 3-D partitions. The Siemens interface is biased towards showing the number of final images and image spacing. The image spacing is variable; it is not limited to the slice thickness and half the slice thickness. In some cases, the slice spacing is limited to about 60% of the slice thickness, rather than the usual 50%. These factors conspire to make it a little challenging to set up a zero-filled protocol with exactly 16 partitions. The easiest way to do this is to turn the "introduction" off in the sequence card, and set up a protocol with 100% slice resolution, no slice partial Fourier, and no slice oversampling. This gives you the correct acquisition time. As long as this acquisition time does not change while you are altering slice parameters, you are still acquiring the desired number of partitions.

The readout pixel size of the QIBA protocols thus far is 420 mm/256 pixels = 1.64 mm. The matrix size in G.E. lingo is 160 x 256, giving a nominal phase direction pixel size of 420/160 = 2.625 mm. The FoV in the phase-encoding direction is 420 x 0.80 = 336 mm, so the actual number of acquired phase-encoding lines is 160 x 0.80 = 128. On the Siemens interface, this same matrix would be denoted as "128 x 256." The Siemens interface allows selection of a phase-encoding resolution of 62% (159 x 256). The nearest FoV is 81.3%, giving a final matrix size of 129 x 256.

The attainable TR will vary with the gradient performance of the particular machine. On the Avanto, using a mildly asymmetric echo ("38%"), the fast gradient mode (System card) will allow TR values below 5 ms. Taking this as a nominal value, the measurement time is

0.005 sec TR x 129 phase-encoding lines x 16 measured partitions = 10.32 sec

Since we will use a slab that covers the entire phantom (about 96 mm), we are not concerned with slice oversampling to avoid wraparound. We are more concerned with the edge effects of the slab profile. Based on our experiments, adding (automatic) oversampling in the user interface does not change the thickness of the slab excited by the RF pulse. To avoid some brightness observed in the first and last partition, it would be useful increase the slab thickness (and the RF excitation) from 96 mm to 110 mm using thicker partitions, and then discard the first and last partition manually. Finally, we would like to zero-fill to obtain the maximum number of output images available. These considerations lead to the following values—I worked these out theoretically, but have not been able to obtain machine time to check them.

	parameter	w/o zero fill	w/zero-fill
visible on user interface	output slices	16	26
	spacing (“thickness”)	6.8 (not available)	4.25
	slab thickness	---	110.5
	slice resolution	100%	63%
not on UI	measured partitions	16	16
	true thickness	6.8 (not available)	6.75

If the gradient power supplies do not permit a TR of 5 ms, one “notch “ of phase-direction partial Fourier may be added to reduce the measurement time.

Additional Explanatory Notes from an E-mail:

Slice Overlap in 3-D

It's useful to compare 3-D slices (partitions) to their 2-D counterparts. We have no difficulty discussion the acquisition of sequential, and perhaps overlapped 2-D slices. If the right half-amplitude point of one slice touches the left half-amplitude point of the next slice, we say that there is no gap, and we say that the slice thickness is equal to the slice spacing. Some people call these contiguous slices. For 3-D measurements, the sinc-shaped slice profiles cross at the 64% point, not at the 50% point, so they are slightly overlapped by our 2-D definitions. In a 3-D data set, we can place a real slice anywhere we want (it is not just some grubby interpolation). In particular, we can add N zeros to N data points (I never know whether to call this a “1X zero-fill” or a “2X zero-fill”) to create a second set of legitimate slices between the first ones. The true slice thickness is unchanged. For the G.E. QIBA protocol, the slices are correctly described in the UI as 8 mm thick with a spacing of 4 mm. Thus we acquire 16 very slightly overlapping partitions of 8 mm in thickness. After zero-filling, we get 32 partitions that are 8 mm thick and overlap a lot--they are spaced at intervals of 4 mm. I would not want to call these "32 4-mm sections" and I would not want to call them "contiguous," because some people will associate these terms with the ordinary (non-zero-filled) 3-D situation, and will think that we have magically created 32 sections, 4 mm thick, and spaced by 4 mm.

The Siemens zero-filling is not limited to "2X," but this can make it hard to visualize. One visualization is that the user interface allows you to place a number of additional slices of the same thickness into the 3-D slab, and these slices are distributed evenly over the 3-D volume (i.e., the slice overlap will depend on how many slices you request). An interesting consequence of this is that you might find that only one of your slices is in the "natural" slice position expected for a non-zero-filled matrix. In many cases, the user interface will allow you to double the number of slices, in which case the effect is the same as G.E.'s sliceZip. The QIBA protocol is not one of those cases. The user interface has inputs for the number of reconstructed slices that you want, the spacing of these slices, and a resolution factor that shows the extent of the zero-filling. To see the true slice thickness, you divide the spacing by the resolution factor. To see the number of acquired partitions, you multiply the number of reconstructed slices (including oversamping) by the resolution factor.

The G.E. user interface is set up to double the number of output slices with one click—the slice thickness is unchanged and the spacing is halved. The Siemens user interface is set up to reduce the measurement time (often not by a factor of two) with one click. You need to make three changes to use the G.E. zero-filling interface to reduce measurement time, and you need to make three changes to use the Siemens zero-filling interface to double the number the number of slices without changing the thickness. For the Siemens UI, these are:

1. setting the slice resolution to 50%
2. reducing the slice “thickness” (really spacing) by half
3. doubling the number of (output) slices

Under certain conditions, the minimum slice resolution will be somewhat greater than 50%. This is intended to prevent the user from requesting overly-thick 3-D partitions, which is unfortunately what the QIBA protocol is using. I do understand that this “protection” applied inconsistently, as shown by the table above.