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Fastest FLASH and EPI with ramp sampling

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Motivation: FLASH and EPI

FLASH (Fast Low Angle Shot Imaging)

- Faster than RARE but slower than EPI.
- Image resolution is better than EPI.
- Implemented by GRE.
- For PD weighting:(Small flip angle, long TR and short TE)
  T1 weighted: (Large flip angle (70°), short TR (less than 50ms) and short TE)
  T2* weighted: (Small flip angle, some longer TR (100 ms) and long TE (20 ms))
- Low SNR, low SAR.

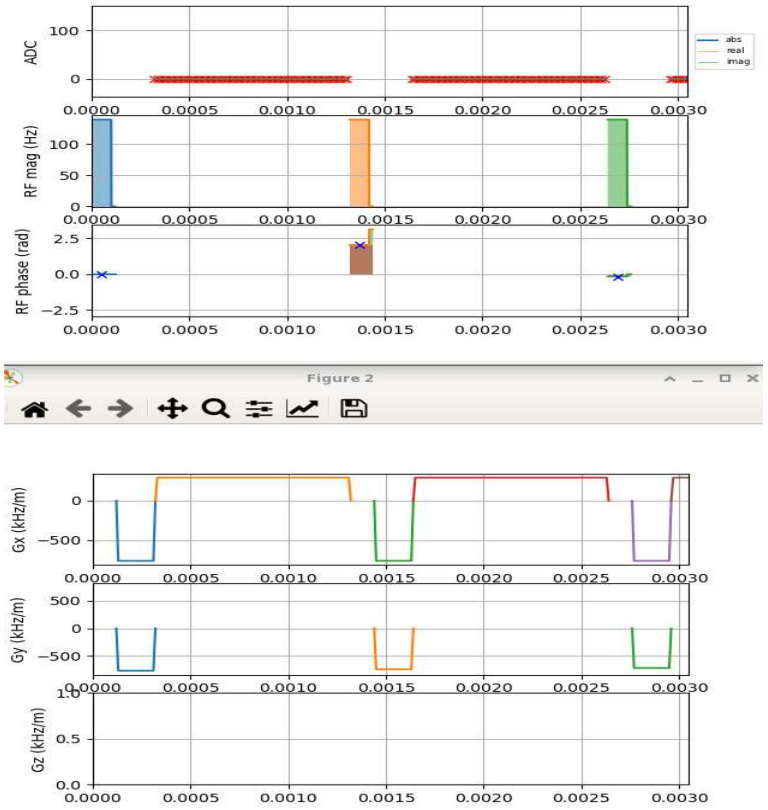
EPI (Echo Planar Imaging)

- Fastest sequence.
- Image resolution is lower than FLASH.
- Implemented by GRE and SE.
- Follows a snake like trajectory throughout the k-space.
- Supports only T2 weighting.
- SNR efficient.

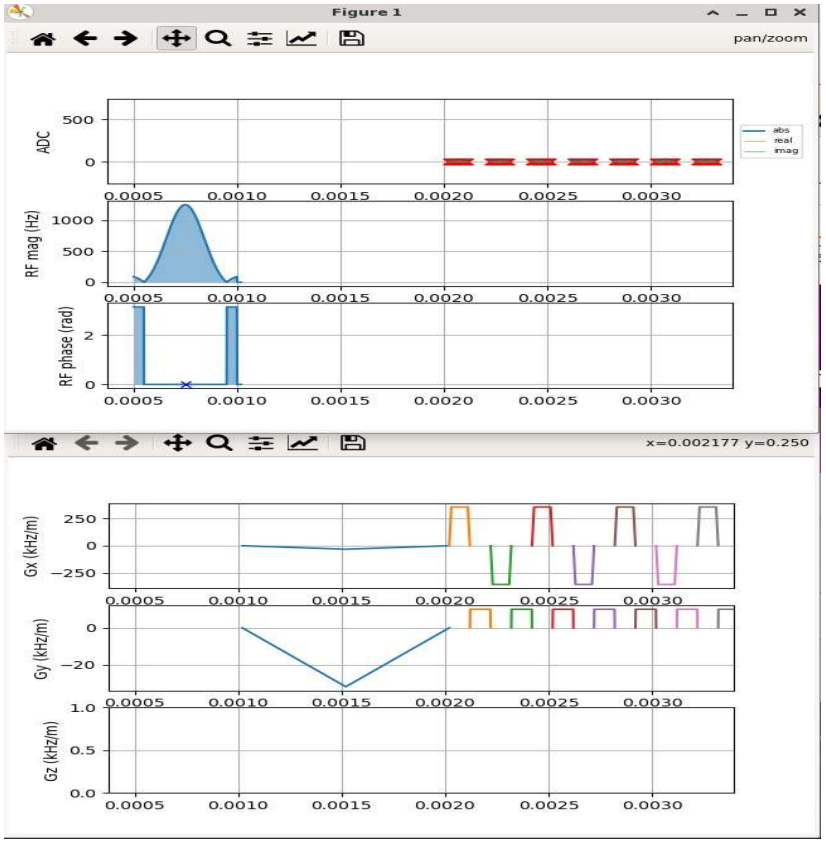
Applications of FLASH and EPI

- Angiography: FLASH sequences can be employed for magnetic resonance angiography (MRA) to visualize blood vessels non-invasively. They are particularly useful for imaging the vasculature of the brain, neck, and peripheral arteries.
- Dynamic Imaging: FLASH sequences can be employed for dynamic contrast-enhanced MRI (DCE-MRI) studies, which involve the repeated acquisition of images before, during, and after the injection of a contrast agent. This technique is used to assess tissue perfusion, particularly in tumor imaging.
- FLASH sequences are even used to scan abdominal regions.
- EPI is commonly used in fMRI to map brain activity. It can capture rapid changes in blood oxygenation levels, allowing us to identify areas of the brain that are active during specific tasks or stimuli.
- EPI is well-suited for capturing diffusion-weighted images, which provide info about the movement of water molecules in tissues. DWI is essential in detecting and characterizing strokes, tumors etc.

Sequences



i)FLASH Sequence



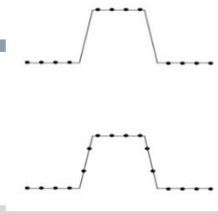
ii)**EPI Sequence**

Scanner Parameters

- Latest clinical scanners with 7T can go from 80 to 200 mT/m gradients whereas we have used here 28 mT/m for our simulation.
- The clinically used slew rate is around 150-200 T/m/s. We have used 150 T/m/s for our simulation. The slew rate influences the minimum attainable TR and TE for conventional MR imaging and influences the echo spacing in fast spin echo and echo planar applications.
- Slice thickness-affects our resolution/Always select best suitable slice
- FOV-helpful for removing of N/2 ghosts
- Matrix size-64*64 to 1024*1024 possible
- Resolution-10mm(varies from scanner to scanner)
- The average FLASH sequence takes around 0.2-2.5s but we were able to get it in 0.07s.
- The average EPI scan takes around 0.05-0.1s whereas we were able to get it in 0.008s.

Magnetic Resonance Technology IP - Protocol Exchange (mr-tip.com)
Reducing SAR - Questions and Answers in MRI (mriquestions.com)

Roadmap



Aim was to make the sequence as fast as possible.

Adding rise time/increased slew rate has made the sequence faster.

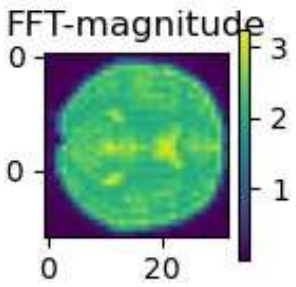
RAMP sampling improves image resolution for EPI

Adding block pulse has reduced time in FLASH sequence.

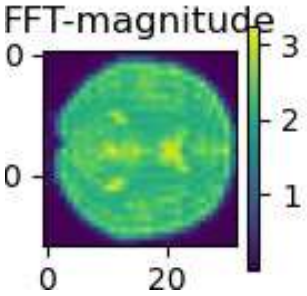
ADC dead time and RF Dead time reduced to 0

Interpolation and regrinding has helped to improve image quality in both the sequences.

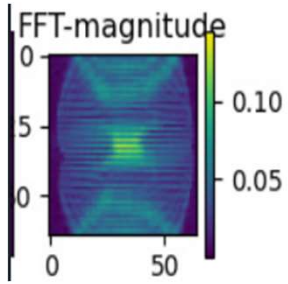
FASTER sequence with good image quality



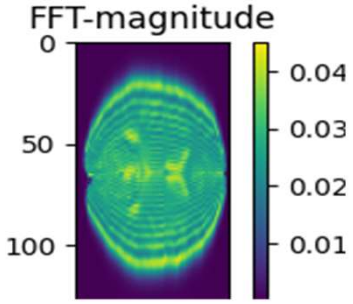
EPI with B0* =1



EPI w/o regrid



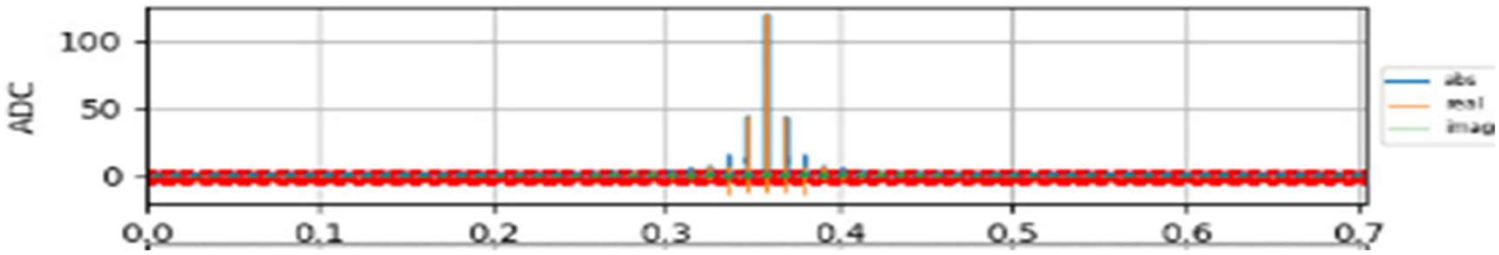
N/2 ghost



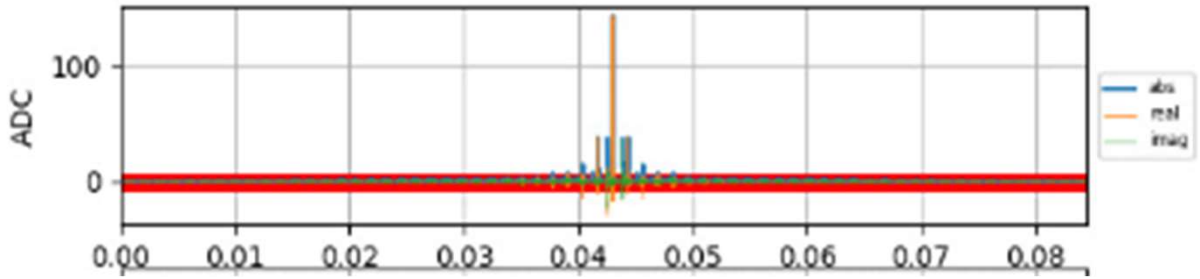
Gibbs Ringing

https://makeameme.org/meme/yes-victory-5bdc2d

FLASH acquisition time

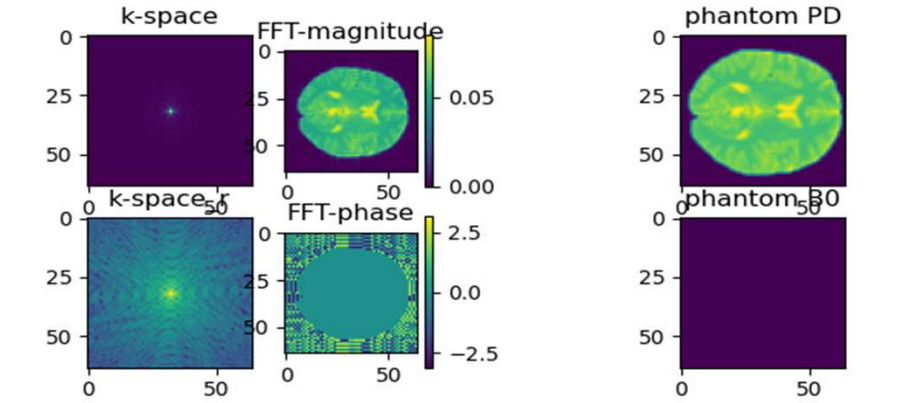


i) FLASH =0.7s / TurboFLASH= less than 500ms

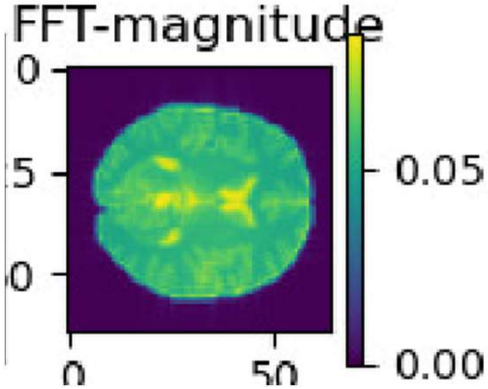


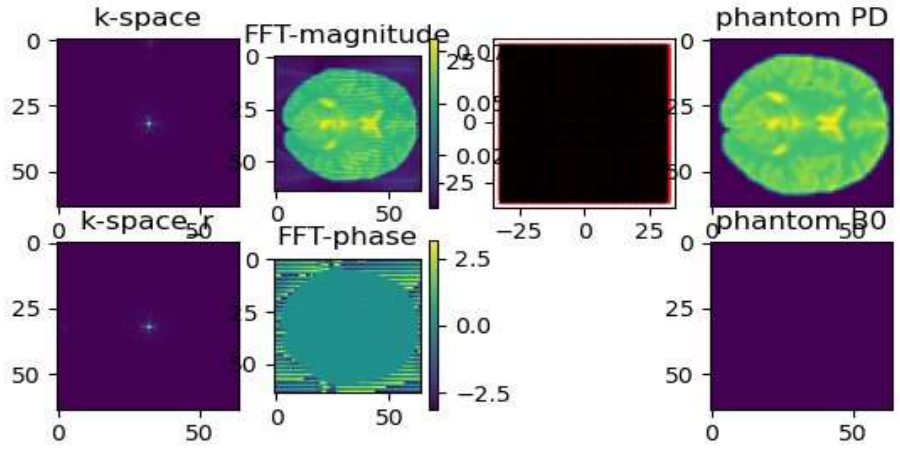
ii) Fast FLASH=0.08s

FLASH Results

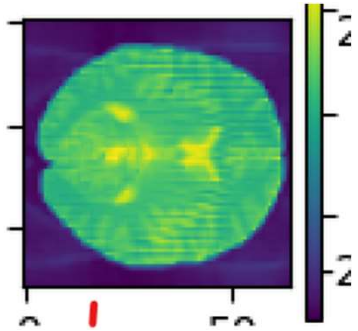


FLASH==>

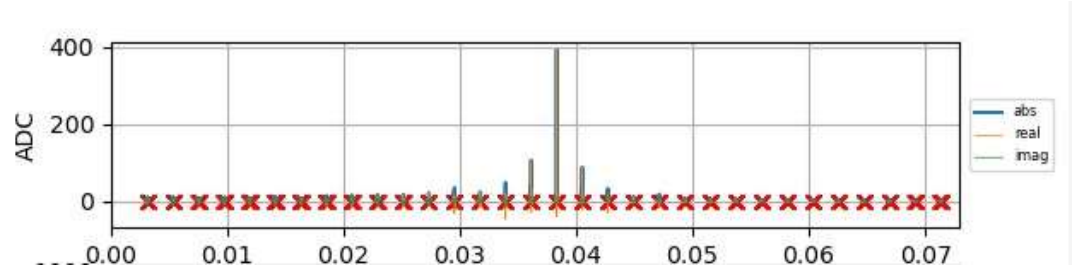




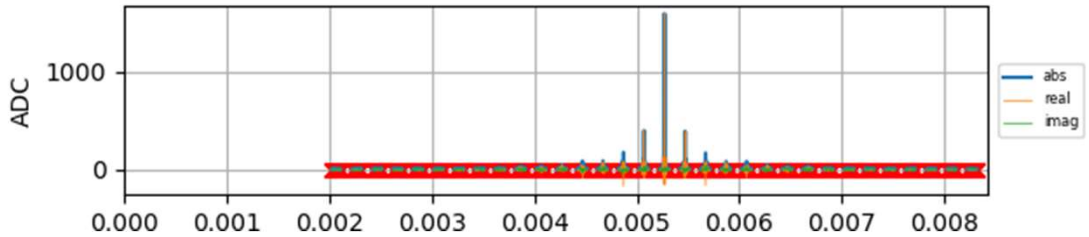
Fast FLASH==>



EPI acquisition time

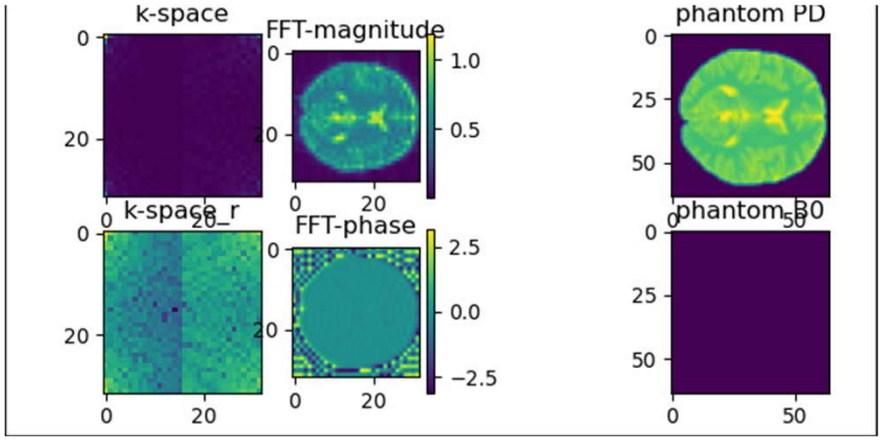


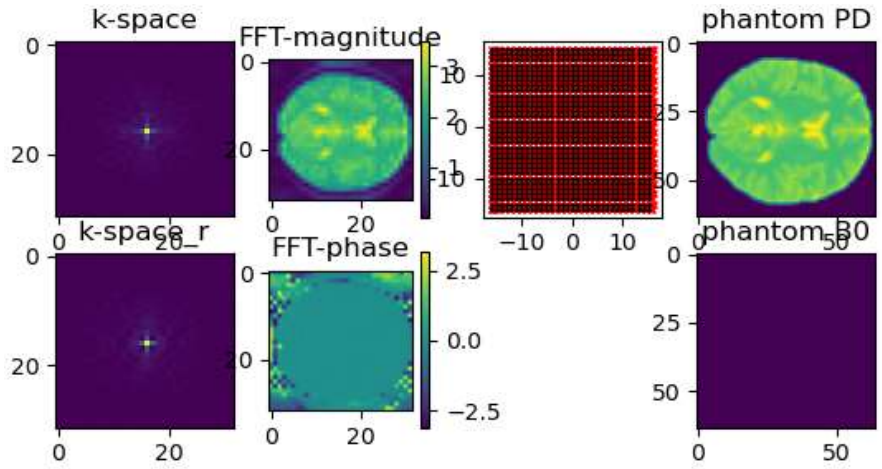
i) EPI



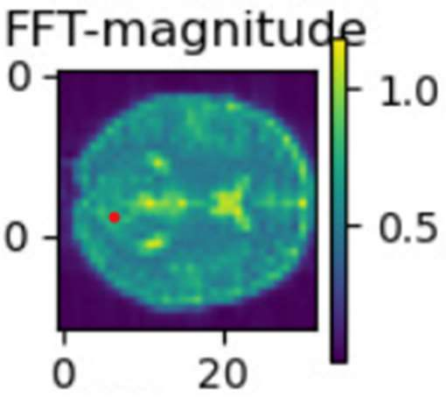
ii) Fast EPI

EPI Results

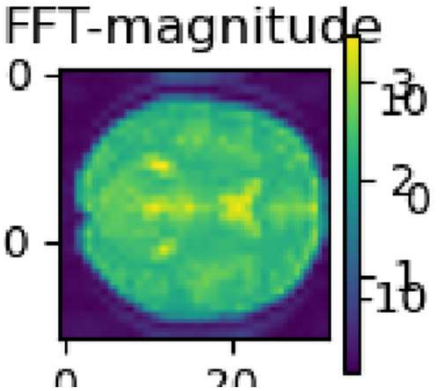




EPI➔



Fast EPI➔



References

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Thank You