# Dynamic Gradient Spatial-Spectral Pulse

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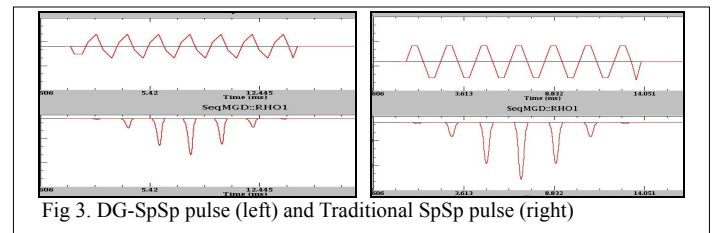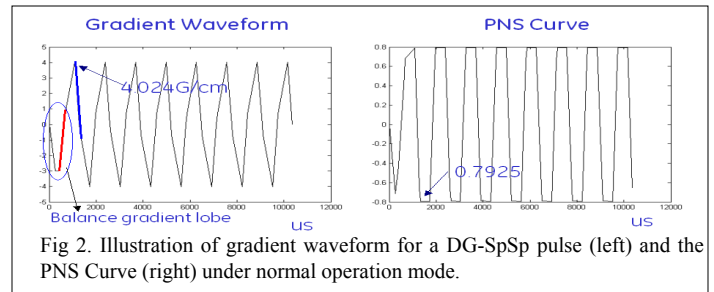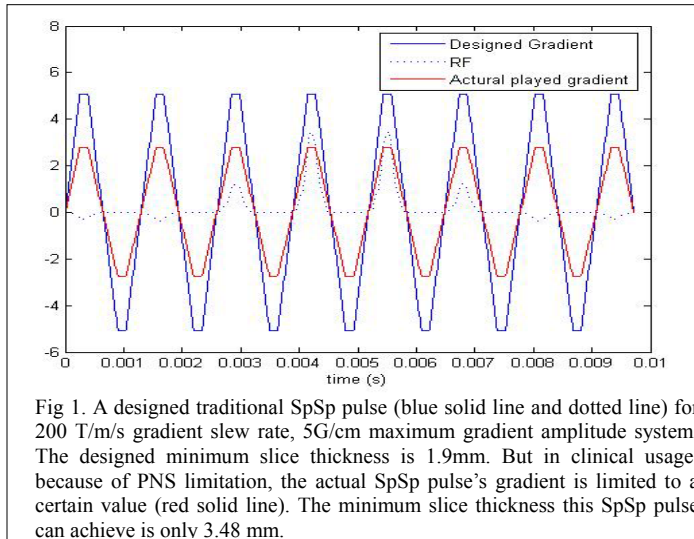[1]MR, GE Healthcare, Beijing, Beijing, China, People's Republic of

## Synopsis:

In this study, a new Spatial-Spectral (SpSp) pulse, called as Dynamic Gradient SpSp (DG-SpSp) pulse, is designed to achieve better minimum slice thickness performance under certain peripheral nerve stimulation (PNS) limitations. And the payment of this improvement is tiny increment of TR time.

## Introduction

Spatial-Spectral pulses have Spatial and Spectral selectivity at the same time. These pulses are widely used in many applications in current MR scanners, especially in Echo Planar Imaging (EPI). However, due to Peripheral Nerve Stimulation (PNS) limitations, the minimum slice thickness that the SpSp pulse can achieve some times is much bigger than intended designed value, hence jeopardizes its value in clinical usage. Figure 1 shows an example.

Compared with traditional SpSp pulse, gradient waveform of DG-SpSp pulse has 2 differences. First, DG-SpSp has one extra gradient lobe, which is called Balance Gradient Lobe, in front of other bipolar gradient lobes. Second, the traditional trapezoidal bipolar gradient lobes are replaced with Dynamic Slew Rate Pulse (DSRP)[1]. The usage of DSRP technique is to alleviate the limitation of PNS on the bipolar gradient lobes. The Balance Gradient Lobe will alleviate the first lobe of the bipolar gradient lobes from limitation even more, this is important because the first one has the biggest impact on PNS limitation among the bipolar gradient lobes.



Fig 1. A designed traditional SpSp pulse (blue solid line and dotted line) for 200 T/m/s gradient slew rate, 5G/cm maximum gradient amplitude system. The designed minimum slice thickness is 1.9mm. But in clinical usage, because of PNS limitation, the actual SpSp pulse's gradient is limited to a certain value (red solid line). The minimum slice thickness this SpSp pulse can achieve is only 3.48 mm.



Fig 2. Illustration of gradient waveform for a DG-SpSp pulse (left) and the PNS Curve (right) under normal operation mode.



Fig 3. DG-SpSp pulse (left) and Traditional SpSp pulse (right)

## Methods

DG-SpSp pulse can be designed through below steps.
1. The Trapezoidal gradient lobes are transferred to DSRP gradient lobe.
2. Add a new gradient lobe before bipolar gradient lobes, which is called Balance Gradient Lobe (Fig 2). This lobe has less gradient value than other gradient lobes, usually 60-80% of the bipolar gradient will be OK. The result of adding this Balance Gradient Lobe is that the PNS generated by the ramp down of the first bipolar gradient lobe (blue line) can be partially compensated by the ramp up of the Balance Gradient Lobe (red line). Hence bring down the total PNS value. In other words, SpSp pulse can use higher gradient value.
3. Since the gradient waveform has been changed, in order to get same slice profile, the RF waveform needs to be changed accordingly.

Figure 3 shows a DG-SpSp pulse (left) designed from a traditional SpSp pulse (right) by above steps.

## Results

Table 1 lists the minimum slice thickness performance of DG-SpSp and traditional SpSp pulses under normal and 1st control operating mode. One can see, both in normal mode and 1st mode, DG-SpSp pulse can excite much thinner slice than traditional SpSp pulse can.

From IQ stand point of view, images from DG-SpSp pulse are comparable with which from traditional SpSp pulses. Volunteer scan were conducted on a GE 1.5T scanner, and images are shown in Figure 4.

## Discussion

By adding Balance lobe in the front, DG-SpSp pulse has bigger pulse width compared with traditional SpSp pulse. The increment is about 1ms. This increment has limited impact in DWI because of long TR, and it does not impact TE.

Theoretically speaking, DG-SpSp pulse can have same slice profile as traditional SpSp pulse. This statement is supported by phantom and volunteer images, but more work in deeper level in this area is needed in future.

DG-SpSp pulse is more vulnerable when gradient and RF are not perfectly synchronized. Based on simulation result, the impact is acceptable as long as the delay is below 8us.

## References

1. Dynamic Slew Rate Pulse (DSRP) for PNS alleviation, Lai Yongchuan, Poster 1459, ISMRM 2010.

| Minimum Slice thickness | Normal mode | 1st mode |
|---|---|---|
| Traditional SpSp pulse | 3.48mm | 2.78mm |
| DG-SpSp pulse | 2.67mm | 2.19mm |

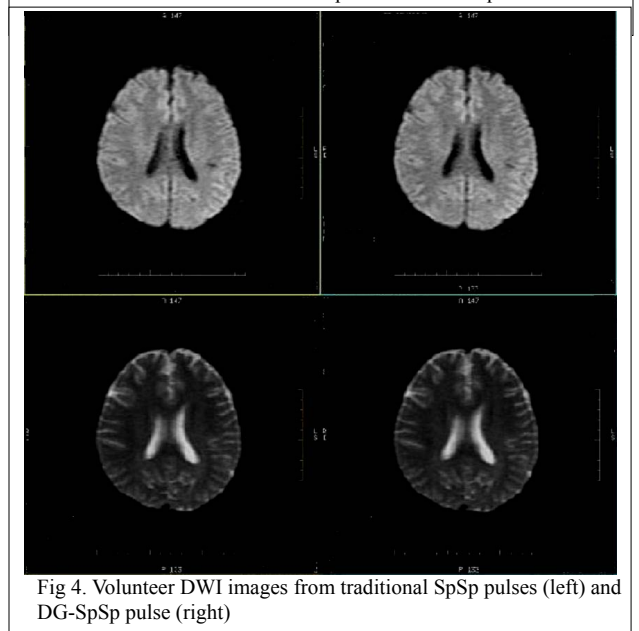Table 1: Minimum slice thickness performance comparison between



Fig 4. Volunteer DWI images from traditional SpSp pulses (left) and DG-SpSp pulse (right)