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1- OVERVIEW

External time-varying magnetic forces can cause disturbances of the magnetic field inside the magnet and thus affect the output image through ghosting and blurring. These external forces are usually caused by large scale moving metals such as cars, trucks, elevators, trains, etc. in the general vicinity of the magnet.

Due to the magnet design, the OpenSpeed System is more susceptible to these external forces, and therefore compensation must occur. The Dynamic Frequency Monitoring (DFM) component of the OpenSpeed System accomplishes this by measuring the effects of these external magnetic forces and then compensating for them during image reconstruction. The DFM subsystem is sometimes also referred to as "Navigator."

2- EFFECTS OF MOVING METAL

An external magnetic force can cause a disturbance of the homogeneous magnetic field B_0 of the magnet, which results in a shift of the resonant center frequency. When this external force comes from a time-varying source such as moving metal (cars, elevators, trucks), it causes the B_0 and hence the center frequency of the magnet to also become time-varying. This unstable center frequency results in a blurred image.

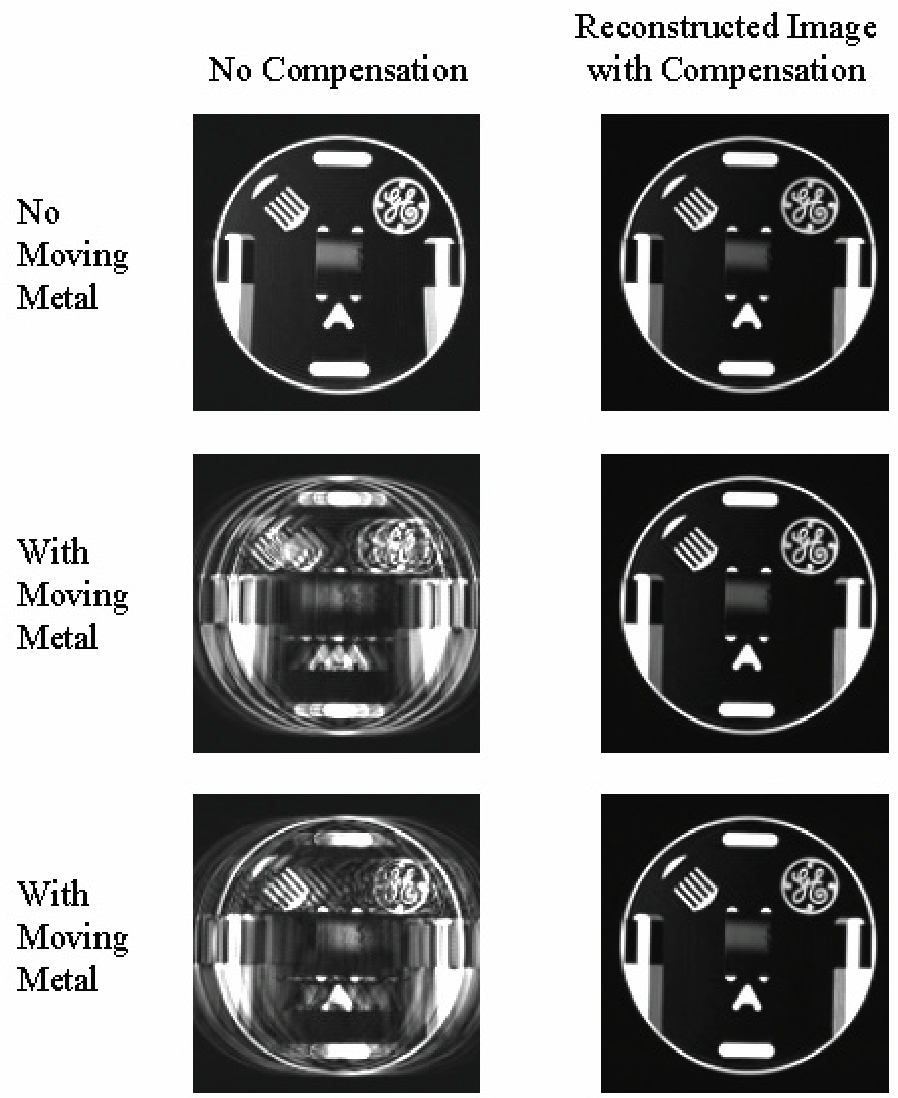
Based on observations, the shifts in center frequency due to moving objects tend to occur smoothly over the course of 0.5 to 2.0 seconds, with the peak displacement of the center frequency varying from a few Hz (cars) to tens of Hz (trucks or larger).

2-1 DFM Compensation Method

The DFM approach to resolving time-varying external magnetic forces involves:

1. Tracking and recording the observed resonant center frequency during a scan using NMR principles
2. And then compensating for the differences from the expected steady resonant center frequency during image reconstruction.

2-2 Moving Metal Illustration Example



DFM COMPENSATION WITH PHANTOM
ILLUSTRATION 2-1

3- DFM COMPONENTS

The DFM system consists of four major components: the Puck, the Puck Interface (PIF), the Transceiver, and the Power Supply. Refer to Direction 2241393 *Block Diagrams and Supplemental Schematics*.

3-1 DFM Puck

The DFM Puck is a small device mounted in the bottom portion of the Body RF coil just below the isocenter of the magnet. It contains a small sample solution of Copper Sulfate ($CuSO_4$) in a vial encompassed by RF coil, called the RF Probe. The RF Probe is also encompassed by the Puck's own X, Y, Z, and Z2 shimming coils, which are used to shim the Puck to achieve a more homogeneous magnetic field within the sample.

3-2 DFM Puck Interface (PIF)

The PIF is mounted at the bottom of the right rear magnet post. It is a Transmit/Receive (T/R) Switch comprised of de-coupling diodes, ¼ wave transmission line, and a receive preamplifier.

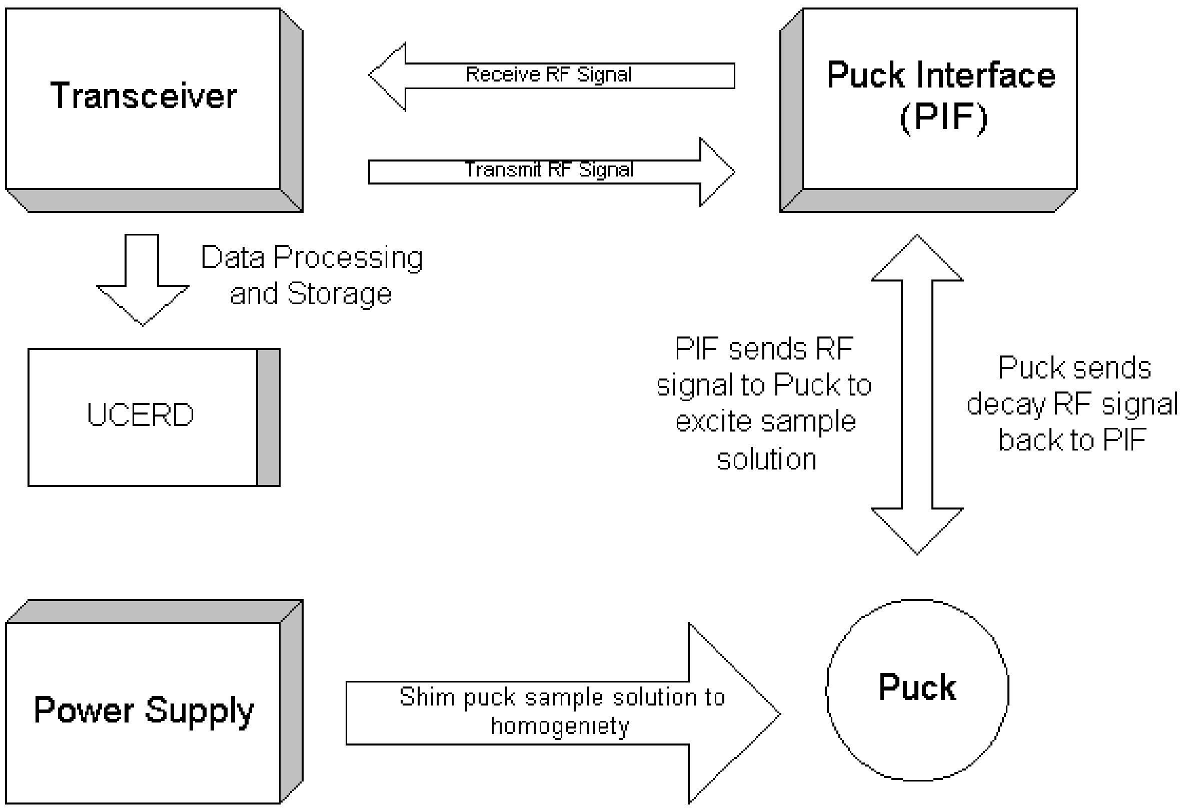
3-3 DFM Tranceiver

The DFM Transceiver Module is mounted in the Systems Cabinet. The module consists of a switchable RF low power (<1 watt) amplifier for transmitting signals and a multiplexing switch for receiving signals.

3-4 DFM Power Supply

The power supply for the DFM System is mounted within the Systems Cabinet and supplies the shimming current to the Puck's shim coils (X, Y, Z, and Z2).

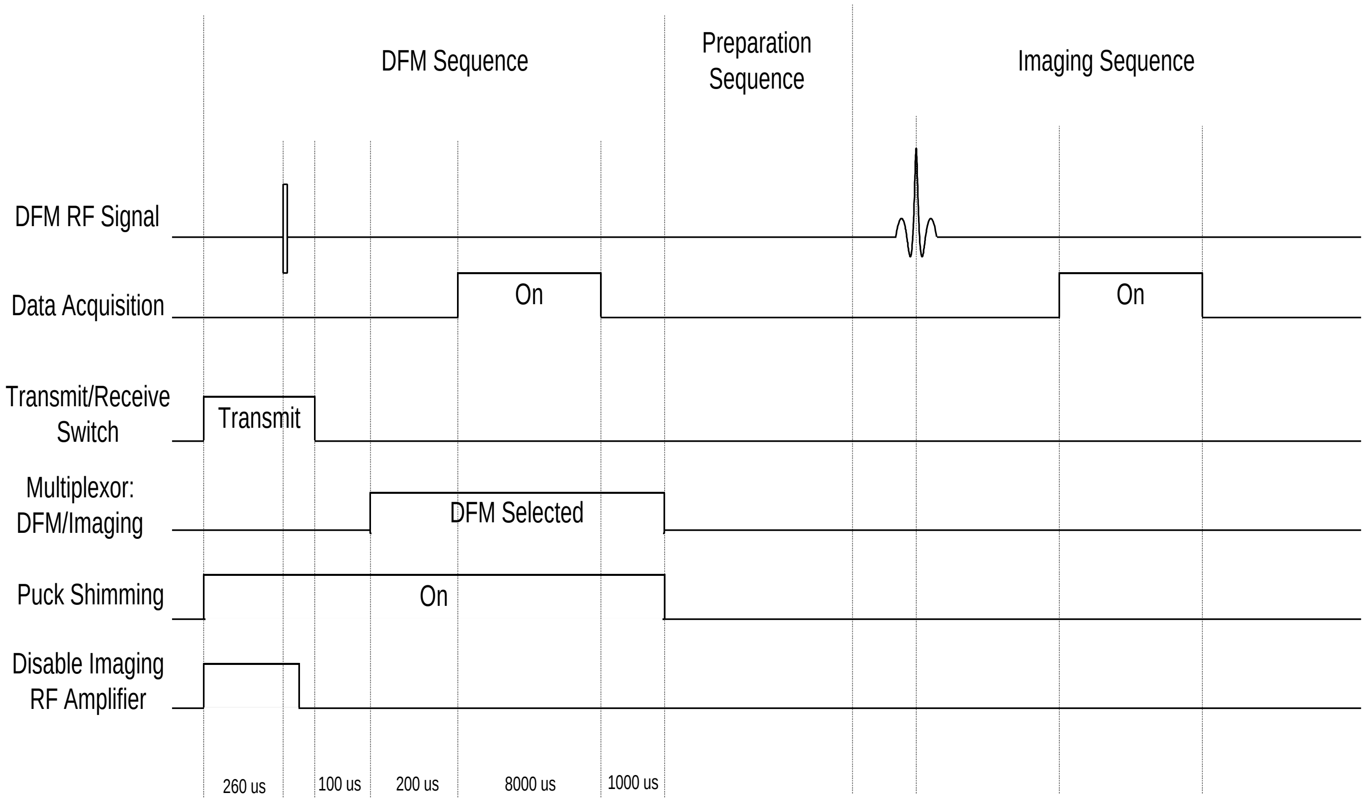
4- FUNCTIONING SEQUENCE



BLOCK DIAGRAM
ILLUSTRATION 4-1

At the start of an MR scan, the host reads the MR configuration file for stored calibrated DFM Shim currents, and communicates to the Shim Supply to set these levels on the DFM X, Y, Z, and Z2 Channels. Then, a "Shim_On" signal enables the amplifiers to turn on and an RF Pulse is transmitted from the Transceiver's RF Amplifier to the PIF. At the PIF, the T/R Switch routes the signal to the Puck, where it excites the sample solution. During the Navigator receive phase, the signal from the Puck is received by the PIF, where it goes through a pre-amplifier. The signal is then sent to the Transceiver, where it is multiplexed with the head coil to receiver zero. The received signals are then recorded and sent to the software so that B_0 compensation can be applied, and the reconstructed image is accurate. The overall Navigator compensation process is interleaved within the scan.

4-1 Timing Diagram



DFM SEQUENCE TIMING DIAGRAM
ILLUSTRATION 4-2

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
A	June 16, 2000	R. Liu	Initial Release
A1	June 20, 2000	R. Liu	Added block diagram, changed labels on timing diagram for clarity
B	Aug. 3, 2000	R. Liu	Changed name from Navigator to Dynamic Frequency Monitoring (DFM)