A Digital Cartesian Feedback Loop for the MRI Transmitter

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Introduction

Functional MRI (fMRI) and Diffusion-weighted MRI (DWI/DTI) are two important MR applications which are known to be sensitive to random system instabilities. The RF power amplifier and the transmit path usually are major contributors to this non-perfect system behavior. In literature, some approaches to stabilize transmit power by means of feedback loops are described [1-3]. We present an all-digital cartesian loop, which turns out to be a very flexible and efficient implementation of feedback and helps to improve transmitter stability significantly.

Methods

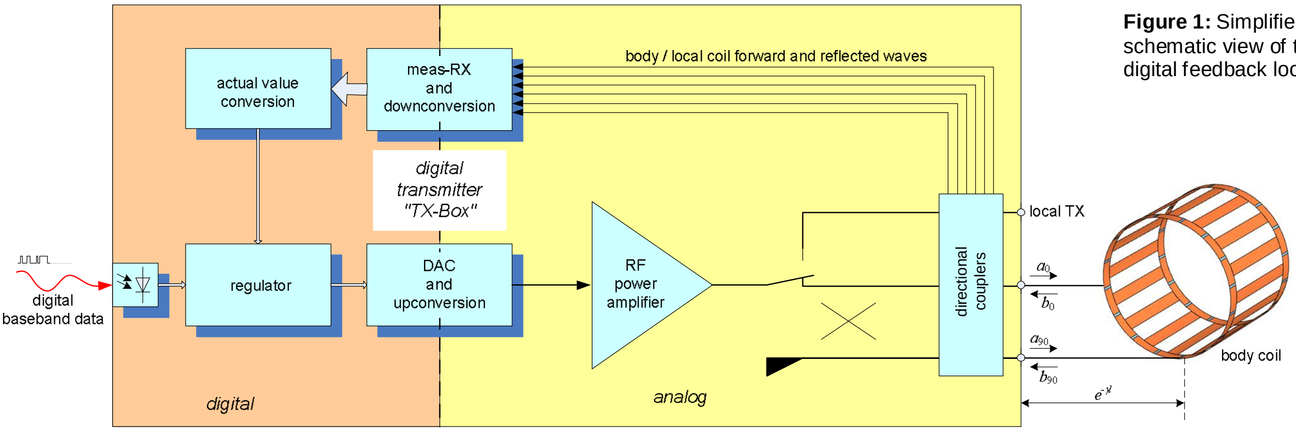

Figure 1: Simplified schematic view of the digital feedback loop

The feedback loop is implemented completely in the digital part of the transmitter hardware and can thus be configured flexibly according to application-specific needs. In the cartesian loop architecture, correction terms for the real and the imaginary part of the baseband transmit signals are fed back and added to the original baseband inputs. Thus, there is no need to deactivate the feedback for low-level signals which is a major advantage compared to previously presented polar loop designs.

The actual value is based on the signals measured with directional couplers and high-accuracy measurement receivers. In the digital actual value conversion block, these signals are combined mathematically to form the actual value which is kept identical to the set baseband data by the feedback loop. During the tests two different modes of operation were considered. In forward power control the actual value is set to a weighted complex sum of the forward waves

$$a = \frac{1}{\sqrt{2}}(a_0 - j \cdot a_{90})$$

The second mode of feedback operation is the control of the actual B1-field. B1 is proportional to the voltages at the feed points of the body coil. As the electrical length and losses between these feed points and the calibration plane of the digital transmitter is well known, these voltages can be derived from the measured wave parameters in the TX-Box calibration plane.

$$u = \frac{1}{\sqrt{2}}\left((a_0 - j \cdot a_{90}) \cdot e^{-\gamma\ell} + (b_0 - j \cdot b_{90}) \cdot e^{+\gamma\ell}\right)$$

Results

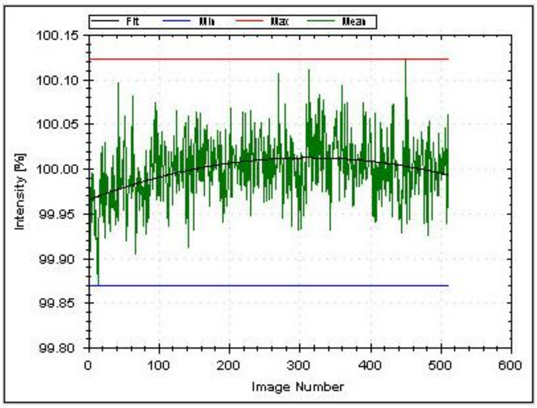

Figure 2: Long-term stability test with B1 control, 512 EPI images with low flip angle of 30°, graph shows average image brightness in a 15x15 ROI, peak-to-peak variation is only 0.25%

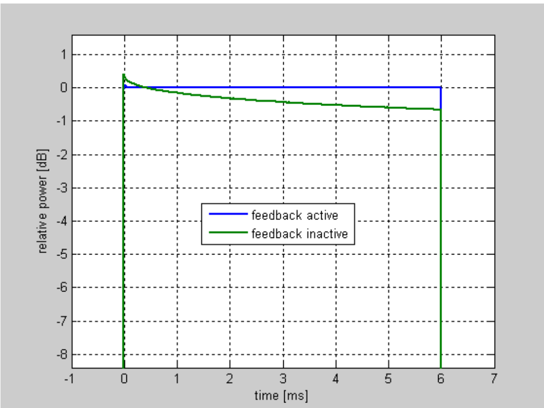

Figure 3: Droop of rectangular pulse with a width of 6 ms and an amplitude of 915 V with and without forward power control, droop is completely eliminated with active feedback

References

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