

Realisation of a flexible power measurement application for Parallel Transmit

G. Kudielka¹, M. Vogel¹, and W. Loew¹

¹Imaging Technologies Europe, GE Global Research, Garching, Germany

Introduction

Radio Frequency (RF) field distortions are a reality on high-field MRI systems due to RF field focusing in the human body. In Parallel Transmit (PTx) independent adjustable transmission paths are used to correct these distortions. However standard SAR measurement methods can no longer be used in PTx [1]. It is shown that amplitude and phase differences between the transmit channels have significant effects on SAR, especially if it comes to “worst case” scenarios like RF amplifier failures [2]. A flexible power monitor setup was developed to control the output of any PTx transmit system during scans and to detect any malfunctions in this system.

Methods

The setup and software is connected on a GE Excite HD 3T MR scanner, equipped with a 16 channel TEM body transmit array coil and eight 8kW RF amplifiers. To monitor the forwarded power in each of the eight RF transmit channels, the setup in Fig. 1 was implemented. A power sensor (Rohde&Schwarz, NRP-Z11) acquires the power from the 30dB directional couplers of the amplifiers. The channels are switched to this sensor with a multiplexer board used in its Switch Mode (National Instruments, SCXI-1193 connected via SCXI-1000 and USB-1359 to USB port). To achieve correct power values, the measurement is synchronized with the MR system by using the Unblank signal – a trigger slope on RF excitation - from the systems RF exciter. The trigger signal is shared between the power sensor and the CTS line of the computers serial port and is detected by the software application.

The application is written with LabView 8.0 and provides a scope view of the acquired power (Fig. 2). LabView drivers were supported to control the power sensor and the multiplexer. Two modes for power control are provided. Each single channel can be selected and the power signal of every excitation is plotted on the scope. The second mode provides a step-by-step switching through channels 1 to 8. After trigger detection the power of the actual channel is acquired followed by forcing the switch module to connect to the next channel. To monitor the power stability during scans the variance is checked. The means M_i of channels power are checked to stay within 3σ from the historical mean μ with:

$$\bar{\mu} = \frac{\sum_{i=1}^N M_i}{N} \quad \sigma = \sqrt{\frac{\sum_{i=1}^N (M_i - \bar{\mu})^2}{N-1}}$$

In case that the threshold of 3σ will exceeded, a signal line from the serial port connected to an amplifier control circuit will stop the excitation of all amplifiers.

Results

The trigger function of the LabView application was validated with a signal generator in pulse mode connected to the serial connection of the computer. The application was modified to measure the time between two changes in the switch state. A delay in switching was detected with pulse periods below 250ms. The RF measurement and connection state of the switch was validated with proprietary software from the manufactures (Rohde&Schwarz, National Instruments). The power measurements were in a range of 1dBm and 100 ns.

Discussion

The limiting factor in this setup is mainly the USB transfer rate. Performance controlling of the application showed that the switching and the read out of the power sensor takes the most system time and leads to delays. We are further optimizing the response time by modifying the software control of the USB devices. Also usage of PCI communication is explored. However this setup and the program shows up an easy and flexible solution to control the RF power for PTx systems with a scalable number of transmit paths. Due to its flexibility, it demonstrates also a development platform for new algorithms.

Acknowledgement

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Reference:

- [1] Seifert F, Wübbeler G, Junge S, Itermann B, Rinneberg H. Patient safety concept for multichannel transmit coils. J Magn Reson Imaging. 2007 Nov;26(5):1315-21.
- [2] Graesslin I, Falaggis K, Vernickel P, et al. Safety considerations concerning SAR during RF amplifier malfunctions in parallel transmission. In: Proceedings of the 14th Annual Meeting of ISMRM, Seattle, WA, USA, 2006 (Abstract 2041)

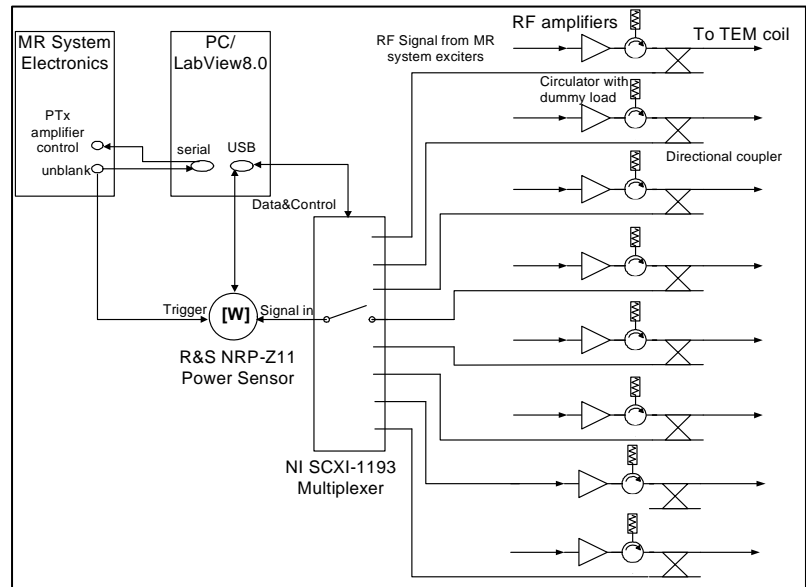


Figure 1 - Schematic of Power Measurement Setup

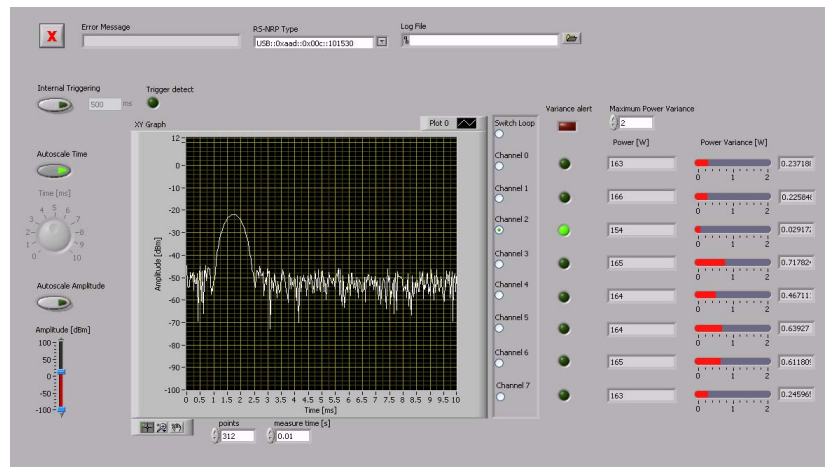


Figure 2 - User Interface of the application