Versatile polarizer NMR spectrometer

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Hyperpolarization of nuclear spins using dissolution dynamic nuclear polarization (dDNP) lead to an increase of SNR in acquired NMR signals [1]. In vivo metabolic spectroscopy [2] and imaging [3] benefited from the boost in sensitivity leading to the development of commercial and home-built polarizer systems [4]. A basic spectrometer monitors the buildup of nuclear spin polarization prior to dissolution. These single-purpose instruments are limited in SNR performance, bandwidth and transmitter frequency.

We herein propose an economical, dedicated polarizer spectrometer based on an integrated self-developed duplexer and the commercially available Magritek Kea2 NMR benchtop console (Fig. 1). The spectrometer operates between 10 MHz - 450 MHz and offers two transmitting and one reception channels thus enabling the use of advanced pulse sequences. The duplexer’s T-R switch relies on PIN diodes and exchangeable λ/4 cables to provide a transmitter-LNA isolation less than +40 dB. An insertion loss less than 1.1 dB is observed during high power transmission (up to 300W using a Tomco TwinPulse 400 amplifier) and reception. High isolation and switching times 1-2 𝜇s fulfil the hardware constraints needed for solid-state NMR. A Miteq AU-2A-150 LNA provides an average gain of 34.5 dB with a noise figure between 1.1 dB - 1.8 dB (Fig. 2).

The Kea2 and a Varian Direct Drive spectrometer were used to acquire $^1$H and $^{13}$C NMR signals for a 4.5 M $[^{13}$C]urea (5:4:1 glycerol-d$_5$, D$_2$O, H$_2$O & 40 mM TEMPOL) sample in a 6.7 T polarizer. The Kea2 spectrometer achieved an SNR of 483.1 and 84.2 with the Varian Direct Drive spectrometer obtaining an SNR of 1636 and 144.9 for $^1$H and $^{13}$C, respectively (Fig. 3).