NMR NOTES #15
Transmitter Power Calculations

The Unity and Inova consoles use linear amplifiers with precision attenuators to provide a range of output power on both the transmitter and decoupler channels. It is important to understand what these powers mean, and how to calculate the power necessary for various applications. Maximum power is +63 db, and minimum power is either 0 (Unity) or -16 (Inova). There is no absolute limit on the power used for different experiments, but an estimate of the normal range of values for various applications is:

Power level (tpwr/dpwr)	application
50 -> 63	Hard pulses
35 -> 50	Heteronuclear Decoupling
20 -> 35	Shaped pulses
5 -> 20	Homonuclear decoupling, water presaturation
-16 -> 10	Spin tickling, n.O.e. difference spectra

Since the amplifiers are linear, if we know the power at any one point, we can calculate the power elsewhere. It is advisable, however, to calibrate the power at a value near the value you are going to use, to avoid extrapolating too far. Also, calibrated power is normally only needed for the first three applications: hard pulses, heteronuclear decoupling, and shaped pulses. Finally, the linear amplifiers become non-linear at very high power levels, above 58 or 60. Consequently, power calibrations obtained at values greater than 55 should **never** be extrapolated for use at other power levels.

The tpwr and dpwr parameters are in db, which is a logarithmic scale. A change of 3db will double or halve the power into the probe. Since pulse excitation depends on the voltage at the probe, rather than the power, and power is proportional to voltage squared, a change of 6db is required to double or halve the γh2 value measured at the probe. The γh2 value is measure of the field strength of the irradiating field. This value can be used to determine both the pw90 value necessary for pulse experiments as well at the dmf value necessary for decoupling experiments. Shaped pulses with usually specify explicitly the γh2 value needed for proper operation. It is easiest to think about γh2 (in units of hertz) as the frequency that the macroscopic magnetization vector is driven around the co-linear axis in the perpendicular plane. A γh2 value of 1000 applied along the x-axis in the rotating frame implies that it take 1msec. for the magnetization to complete one revolution around the x-axis in the y-z plane. This would correspond to a 360 degree pulse. It follow immediately, then that pw90, the time for a 90 degree pulse, is one quarter of that 1 msec, or 250μsec. Varian always defines dmf, the decouple modulation frequency, as 1/pw90 since it is always used to time 90 degree pulses. From this then, we can write the basic relationship between these various quantities:

$pw360=1/\gamma h2$ $\qquad$ $pw90=1/(4*\gamma h2)$ $\qquad$ $dmf=1/pw90=4*\gamma h2$

Also, when calibrating power at a new field strength, it doesn't make any difference if we think and calculate in terms of pulse widths, field strengths, or dmf values, since they are all proportional,and we only need the ratio of the two:

$\Delta db=20*\log(P1/P2)$ where P1 and P2 are the two reference power levels, either as γh2, pw90, pw360, or dmf. The only requirement is that you use the same units for both power levels. Note that increasing the value of tpwr/dpwr will increase the power and increase the field strength as measured by the γh2 value. This will correspond to a larger dmf value and a shorter pulse length.

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