

## SolidsPack for the Varian NMR System

### Dave Rice – 2007-02-01

#### SolidsPack

SolidsPack is a new archive of pulse sequences for the Varian NMR System that has been in the Userlib since December of 2006. The package contains about 90 pulse sequences with VNMRJ templates and protocols. The sequences can be run in either the Experimental interface or the Walkup interface of VNMRJ2.1B. They address all Solids applications including Basic CP/MAS, Quadrupoles, Multiple Pulse and BioSolids. See the appendix of this note for a complete list.

SolidsPack has new documentation. Each sequence has a manual file that describes the purpose of the experiment and the parameters. The more basic sequences include set-up instructions. One can obtain the manual file for a sequence with the *Sequence* Button on the text panel of VNMRJ. The *.README* file can be found in *vnmrsys/maclib* and it contains a list of the sequences and changes. The additional manual file *vnmrsys/manual/SolidsPack* contains a technical description of SolidsPack and instructions for setting up a Solids user. Access this file with *man('SolidsPack')* on the command line. A second file *vnmrsys/manual/SolidsPackChanges* also documents known bugs, fixes and additions. The file *vnmrsys/manual/AllParGroups* lists the *Parameter Groups* that are used by the SolidsPack sequences. See below for more information about *Parameter Groups*.

#### Installation of SolidsPack

To install SolidsPack, download the files *SolidsPack.tar.Z* and *SolidsPack.README* to */vnmr/userlib/psglib*. One must be the *administrator* to do this. Log in to the Solids user in a shell and type “*/vnmr/userlib/extract psglib SolidsPack*”. All files will load into the user and the *.README* file will appear. Further instructions are in the *SolidsPack* manual file. SolidsPack should only be loaded into a new “clean” user directory that will not be used for any other purpose. It can also be loaded over the top of a previous SolidsPack installation. One should not load SolidsPack over the top of previous installations of *solidslib21a* or *solidslib21b*. Certain changes in panels and the new use *probeConnect* make SolidsPack incompatible with SolidsLib. SolidsPack should not be used with <sup>UNITY</sup>*INOVA*.

“SolidsPack” has been chosen as a new name to designate sequences for VNMRs only. In addition the sequences of SolidsPack use different conventions for parameters from the older SolidsLib. The name “SolidsLib” continues to designate sequences for <sup>UNITY</sup>*INOVA* and *SolidsLib.tar.Z* remains in the Userlib on the VNMRJ2.1B CD. *SolidsPack.tar.Z* for VNMRs is now on the web and will be found in the Userlib of the next software version. SolidsPack obsoletes *solidslib21a* and *solidslib21b*, which were written for VNMRs.

## Upgrading SolidsPack

SolidsPack is upgraded periodically with new sequences and bug-fixes. Changes in the Userlib version are carefully documented to avoid accidental changes. It is safest to watch for announcements of a new SolidsPack and upgrade at that time. It should be noted that a second file called *vnmrssolids2.tar.Z* is present on the FTP site in */chemagnetics/NMR\_SYSTEM\_SOLIDS/*. This file is the applications-lab archive of potential changes to SolidsPack. One can upgrade a SolidsPack user with this file if a feature is needed immediately. Upgrade again from the Userlib when the feature is in SolidsPack to insure that your installation remains under version control. New sequences can also be loaded individually. Future upgrades do not affect these sequences unless they have been incorporated into SolidsPack with the same name.

## Basic Sequences of SolidsPack

In SolidsPack the so-called “basic sequences” *xpolar1.c* and *xpolvt1rho1.c* have been replaced by several new sequences. The sequence *tancpx.c* provides constant, linear and tangent-ramped cross polarization (the functions of *xpol='y'*) and *onepul.c* provides a single pulse experiment (the functions of *xpol='n'*). A group of other sequences whose names begin with “*tancp*” or “*onepul*” provide the more advanced functions of the original basic sequences, including  $T_1$  and  $T_{1\rho}$  measurements, sideband suppression and dipolar dephasing. It is a general objective in SolidsPack to avoid the use of flags in sequences and to provide one function per sequence.

Note that the VNMRS2.1B *psglib* still contains the standard “installer sequences” *onepulse.c*, *stdcp.c* and *tancp.c*. These sequences are distinct from the basic sequences of SolidsPack and use the older parameter conventions of the SolidsLib.

## Probe Tuning in SolidsPack

SolidsPack provides a special pulse sequence called *tunerp.c*, which measures a phase-detected pulse from the reflected port of the directional couplers. This sequence can be used for “pulse tuning” in a manner similar to *InfinityPlus* and it replaces the need for an external scope, which was needed for <sup>UNITY</sup>INOVA. Instructions for *tunerp.c* are in the manual file.

VNMRS also provides a swept-tune function called *mtune*. To access *mtune* press *Tune Sweep* in the *Probe* popup.

Note that a Solids “high power” lowband preamp can distort the low-power *mtune* sweep and be difficult to use for some nuclei. *Tunerp* can be used with higher power when this situation arises.

## New Parameter Groups

The pulse sequences of SolidsPack provide a significant change in the way one interacts with the parameters of a pulse sequence, through the use of “parameter groups”. A parameter group is set of parameters that define a specific sequence function, for example “cross polarization”, “PMLG decoupling” or “C7 recoupling”. At minimum, a parameter group has an associated “group template file” that defines the interface to the item on the *Sequence* panel of VNMRJ. A parameter group presents the same interface to a pulse-sequence function in every sequence that uses it. The use of parameter groups eases the task of reading and understanding panels in different sequences and logically organizes the functions of a pulse sequence. The group template files are located in *vnmrsys/templates/vnmrj/panelitems* as *.xml* files. These files can be added to the pulse-sequence panel of a user sequence, using the panel editor.

## Modular Pulse Programming

Most often a parameter group is also associated with a set of C-language functions in the pulse-programming language. These functions are referred to as “pulse-sequence modules” or “pulse-sequence objects”. The software for all the modules of SolidsPack is found in the file *vnmrsys/psg/solidstandard.h*. *solidstandard.h* also references the other *#include* files that are located in *vnmrsys/psg*. Every *.c* pulse-sequence file contains the line “*#include <solidstandard.h>*” to attach the modules. Most pulse sequence functions, particularly waveforms and multiple-pulse sequences, are implemented with modules. Modification of a sequence to add a module, for example adding TOSS sideband suppression, usually involves the addition of just two lines of code.

Modular pulse programming improves the reliability of pulse sequences and makes them easier to write. Most bugs arise from coding mistakes or from a misunderstanding of the function of the hardware. Reference to a module avoids the need to copy code and if the module is well tested it hides any difficult issues that might be associated with hardware function. Our goal is to allow users to code more sequences with modules and focus our own attention on producing reliable modules.

The currently available pulse-sequence modules and parameter groups are documented in *vnmrsys/manual/AllParGroups*, along with instructions for using them. In a pulse sequence, the C-functions associated with modules either begin with “*get*” as in *getcp()* or with an underscore as in *\_cp()*. All other statements are standard pulse-sequence elements, which are described in the *VNMRJ User Programming Manual*. One can read the code for the modules in the “*.h*” files of *vnmrsys/psg* and these *.h* files are documented internally. More information about modules can be found in the applications note *Programming with Objects for the Varian NMR System*, which is available on the FTP site in */chemagnetics/NMR\_SYSTEM\_SOLIDS\_Applications\_Notes*.

## New Parameter Naming Conventions

The sequences of SolidsPack use a new method for naming parameters. The adhoc names of the old SolidsLib, for example “dipolr”, “evolve”, “tpwrm”, *etc* have been replaced with systematic names derived from parameter groups. Every parameter name consists of three parts, a lower-case “prefix”, an upper case “channel identifier” and a lowercase “suffix”.

**parameter = prefix + channel identifier(s) + suffix**

The **prefix** identifies the purpose of the parameter. Common prefixes are “a” for amplitude, “pw” for pulse, “t” for delay, “ph” for phase, “of” for offset, etc. An effort is made to keep these designations simple. When a module has more than one parameter of the same type numerals are used to distinguish them, for example *pw1*, *pw2* ... *etc*. Prefix designations are programmed in the module.

The **channel identifier** is one or more upper-case characters that identify the *pulse-sequence* channel (*c.f.* *obs*, *dec*, *dec2* and *dec3*) to which the parameter applies. For SolidsPack we have decided that *obs* = “X”, *dec* = “H”, *dec2* = “Y” and *dec3* = “Z”. This nomenclature is based upon the common understanding of these letters in designating probe channels and an assumption about the typical nuclei that are assigned to *obs*, *dec*, *etc*. It should be recognized though that any pulse sequence channel can be assigned to any probe channel through *probeConnect* and so it is not unreasonable for “*pwX90*” to end up as a proton observe pulse.

The **suffix** identifies the type of the parameter group, for example “90” is a 90-degree pulse, “c7” designates C7 recoupling and “cp” designates cross polarization. An example parameter is *pwHtpm*, the pulse width used in TPPM decoupling. Note that parameter groups that have two or more channel identifiers use lowercase channel identifiers as the first characters of the suffix. For example *aHhx*, the decoupler amplitude of H-X cross polarization uses an upper case “H” to identify the channel to which the amplitude applies and a lower case “hx” to indicate that this is H to X cross polarization. Note that the “cp” suffix is suppressed for the cross polarization parameter group.

Parameter groups themselves are usually named with the **suffix** first and the **channel identifiers** second, so H-X cross polarization is “*cpHX*” (there are a few older exceptions where the order is not reversed).

**parameter group = suffix + channel identifier(s)**

The exact characters used to designate the parameter group (suffix and channel identifiers) are input arguments of the module and are under control of the writer of the sequence. The module automatically attaches the prefixes. It will be necessary to edit a new group template file if one creates a new parameter group name.

With a little experience it should be possible sight-read most parameter groups. They are also fully defined in the manual file of each sequence.

## Protocols and Use of the Walkup Interface for SolidsPack

With VNMRJ21B the Walkup interface can be used to run single-acquisition experiments as well as automation experiments through the Study Q. The Walkup interface provides the “*Experiment Selector*” by which pulse-sequence setup can be accomplished using a “*protocol*”, by a drag-and-drop to the spectral display area. Solids protocols can also be found in the *Experiments* pull-down menu under *Solid-State Experiments*.

Each sequence of SolidsPack is equipped with a “protocol” that can be initiated from the *Experiment Selector*. In principle Solids protocols can also be run from the *StudyQ*, though this feature has not been tested extensively. In practice a protocol (designated with a upper-case first character) performs the same function as a setup macro (lower-case first character). Both can also be initiated by typing on the command line as well. For example the command ***Tancpx*** runs the protocol to set up cross polarization and the command ***tancpx*** runs the setup macro for the same purpose. Both have an identical effect, though they use different functions in VNMRJ.

The protocols of SolidsPack set up the experiment by accessing a parameter file ending in *.par* and beginning with an *upper-case* character. For this reason the *.par* files of SolidsPack in *parlib* all begin with an *upper-case* character. The setup macros do not access a parameter file so there are no lowercase *.par* files.

A special protocol, ***Settancpx***, clears the workspace and loads default solids parameters. All other protocols and all setup macros add their parameters to the existing workspace and they do not disturb existing calibrations.

We recommend the exclusive use of the Walkup interface. All the command-line functions of the Experimental Interface are in fact included in the Walkup interface and the *Experiment Selector* provides an added convenience.

## Pulse-Sequence Conventions for SolidsPack

One should be aware of several other SolidsPack conventions. SolidsPack sequences do not use the *status()* command and do not use the parameters *dm* and *dmm*. Sequences are set up with *dm* = ‘n’ and decoupling is controlled in the sequence. The “*Hseq*” parameter group supplies acquisition decoupling, with a choice of CW, TPPM, SPINAL64 and “off”. The “*Hmix*” group is used for separate decoupling levels during F1 and other mixing periods. Note that in the *seq* and *mix* parameter groups CW decoupling is set with phase = 0.0 (*c.f.* *phHtpm* = 0.0), independent of the decoupling type, and “decoupler off” is set with amplitude = 0.0 (*c.f.* *aHtpm* = 0).

All sequences use an explicit *acquire(np, 1/sw)*; (as did sequences of the SolidsLib). For VNMRS, *startacq(ad)*; replaces *rcvtron()*; *delay(ad)*; and performs some specific setup for the digital receiver as well. The *endacq()* statement follows the *acquire()* statement and performs housekeeping for the next scan. The VNMRS digital receiver has a housekeeping delay of about 200 us, which sets a minimum for *d1* of the next scan.

The values of *rof2* and *alfa* are replaced with *rd* and *ad*, as has been the convention for the SpinSight and the SolidsLib in the past. VNMRS users should also be aware of the new definition of *alfa* (or *ad*) that results from use of a digital receiver.

The new VNMRS parameter *rof3* is usually not defined and that means it has a default value of 2.0 microseconds. For VNMRS *rof3* is the minimum value of *alfa* (or *ad*) when used in the *startacq()* command and it sets the length of the *rcvtron()* command. The value of *rof3* is defined in interleaved-acquire experiments such as BR24 CRAMPS. When using the solids preamp *rof3* need only be as little as a 500 ns.

All SolidsPack sequences make use of the new parameter “*ddrtc*”, “digital receiver time correction”. A spectrum with minimal linear phase correction, *lp*, can be produced by setting *ddrtc* = *rd* + *ad*. Time correction is independent of spectral width and applies to all widths less of 1.25 MHz and less. One can fine-tune *ddrtc* to make *lp* exactly zero.

Note that *ddrtc* always sets the phase correctly but it will not necessarily create a flat base line. For large spectral widths it may be necessary to do some linear prediction. Also a first point distortion from probe ringing can have a nonlinear affect on the correction for small spectral widths. To manage ringing, open the spectral width to 5 MHz and choose *rd* and *ad* so that the first point is good. If the first point is good the time correction should produce a flat baseline for any spectral width where  $ddrtc < 1.0/(2.0*sw)$ .

SolidsPack sequences maintain all amplifiers as “unblanked” throughout the sequence. One will frequently see *obsunblank()* and *decunblank()* commands in sequences. These statements follow standard pulse-sequence elements that leave the amplifier blanked (*c.f.* after *rgpulse()*, *decrpulse()*, *etc*). All of the pulse-sequence modules of SolidsPack leave the amplifier unblanked.

The “unblanked” convention is similar to the default for *InfinityPlus* and the opposite of <sup>UNITY</sup>*INOVA* for liquids. One can also place a VNMRS in “*noblank*” mode to defeat the default blanking between experiments. Unblanking during and between experiments improves amplifier stability and is crucial for sensitive BioSolids experiments that involve XY cross polarization. It has some negative consequences for liquids (such as spin tickling) so *noblank* mode is used only with SolidsPack. See the applications note *Placing a VNMRS in “noblank” Mode for Solids* and it can be found on the FTP site in */chemagnetics/NMR\_SYSTEM\_SOLIDS\_Applications\_Notes*.

SolidsPack sequences generally do not use “flags” to control functions (*c.f.* *xpol* = ‘y’) and have one function per sequence. Flags are no longer needed because one can easily change the pulse sequence name with the *Experiment Selector*. All Solids protocols and

setup macros (other than *Settancpx*) preserve calibrations in the workspace and all sequences use parameters consistently, so one can always change the sequence with a protocol or a setup macro without affecting calibrations.

## Acknowledgement

This programming organization of SolidsPack, using new parameter conventions and modules, resulted from work of Donghua Zhou in the Group of Chad Reinstre at UIUC to produce a BioSolidsPack for <sup>UNITY</sup> INOVA. This software for VNMRS results from work of Chuck Bronnimann and Dave Rice and the SolidsPack package is now maintained by Dave Rice. BioSolidsPack should be obtained directly from UIUC – requests for conversion of the BioSolidsPack sequences for VNMRS should be made to Dave Rice.

## Appendix 1 – Pulse Sequences in the SolidsPack Release – 12/01/06

1. **babainad2d.c** - 1Q-2Q "X" correlation using BABA mixing, with TPPM or SPINAL decoupling.
2. **br24.c** - "X" acquisition with interleaved BR24, non-quadrature phase cycle.
3. **br24q.c** - "X" acquisition with interleaved BR24, quadrature phase cycle.
4. **c7inad2d.c** - 1Q-2Q correlation using C7 mixing, with TPPM or SPINAL decoupling.
5. **c7inadwdumbot2d.c** - A 1Q-2Q correlation using C7 on "X", DUMBO during F1 on "X" and wDUMBOt during F2.
6. **c7inadwpmlg2d.c** - A 1Q-2Q correlation using C7 mixing on "X", PMLG during F1 on "X" and wPMLG during F2.
7. **cpinad2d.c** - A "X" 2D INADEQUATE (1Q-2Q) correlation experiment with tangent CP preparation of "X", with TPPM or SPINAL decoupling. Pulses can potentially be rotor synchronized.
8. **dcp2tan3drad.c** - 2D(3D) double CP with "Y" f1 chemical shift (CN correlation), with "X" RAD mixing and with TPPM or SPINAL decoupling.
9. **dcptan3drad.c** - 2D(3D) double CP with "X" f1 chemical shift (NCO/NCA), with "X" RAD mixing and with TPPM or SPINAL decoupling.
10. **dcptan3dspc5.c** - 2D(3D) double CP with "X" f1 chemical shift (NCO/NCA), with "X" SPC5 mixing, with TPPM or SPINAL decoupling.
11. **decorcptan2d.c** - Onepulse prep on the "Y" channel with "Y" to "X" CP and "X" observe, with SPINAL or TPPM decoupling.
12. **dipshftr12dfs.c** - A spin echo experiment on "X" with "H" to "X" r1235 recoupling on "H" to measure the "H"-"X" dipolar interaction of quadrupole nuclei with DFS enhancement of the "X" signal, with TPPM or SPINAL decoupling.
13. **dcptan.c** - Ramped "H" to "Y" and then "Y" to "X" CP (double), with TPPM or SPINAL decoupling.
14. **fsredor.c** - Frequency selective REDOR using selective Gaussian pulses on "X" and "Y" and XY8 on "Y" with two pulses per rotor period. Acquisition with TPPM or SPINAL decoupling, TPPM only during REDOR.

15. **hetcorlgcp2d.c** - "H" to "X" HETCOR using FSLG during f1 followed by a Lee-Goldburg CP, with TPPM or SPINAL decoupling.
16. **hetcortancp2d.c** - "H" to "X" HETCOR using FSLG during f1 followed by a ramped CP, with TPPM or SPINAL decoupling.
17. **ineptxyonepul.c** - One-pulse preparation of "Y" with INEPT transfer to "X" and observe, with SPINAL or TPPM decoupling. Separate SPINAL and TPPM decoupling are allowed during INEPT transfer.
18. **ineptxyrefonepul.c** - Refocussed one-pulse preparation of "Y" with INEPT transfer to "X" and observe, with SPINAL or TPPM decoupling. Separate SPINAL and TPPM decoupling are allowed during INEPT transfer.
19. **ineptxyreftancp.c** - Refocussed CP preparation of "Y" with INEPT transfer to "X" and observe, with SPINAL or TPPM decoupling. Separate SPINAL and TPPM decoupling are allowed during INEPT transfer.
20. **ineptxytancp.c** - CP preparation of "Y" with INEPT transfer to "X" and observe, with SPINAL or TPPM decoupling. Separate SPINAL and TPPM decoupling are allowed during INEPT transfer.
21. **lgcp.c** - "X" Lee-Goldburg CP, with TPPM or SPINAL decoupling.
22. **masapt1d.c** - An "X" attached proton ("H") test using FSLG homonuclear decoupling on "H", tangent CP preparation of "X", with TPPM or SPINAL decoupling.
23. **mashmqc2d.c** - "H" to "X" J-HMQC with FSLG homonuclear decoupling of "H", tangent CP preparation of "X", with TPPM or SPINAL decoupling.
24. **mashsqc2d.c** - "H" to "X" J-HSQC with FSLG homonuclear decoupling of "H" and tangent CP preparation of "X", with TPPM or SPINAL decoupling.
25. **mqmas3q2d.c** - Two-pulse MQMAS with a 3Q phase cycle, with SPINAL or TPPM decoupling.
26. **mqmas3qdfs2d.c** - Two-pulse MQMAS with a 3Q phase cycle, a DFS second pulse, with SPINAL or TPPM decoupling.
27. **mqmas3qdfsspltse2d.c** - Two-pulse MQMAS with a 3Q phase cycle, a DFS second pulse, a split t1 and a selective echo, with SPINAL or TPPM decoupling.
28. **mqmas3qdfszf2d.c** - Z-filtered MQMAS with a 3Q phase cycle, a DFS second pulse, with SPINAL or TPPM decoupling.
29. **mqmas3qfam2spltse2d.c** - Two-pulse MQMAS with a 3Q phase cycle, a FAM2 second pulse, a split t1 and a selective echo, with SPINAL or TPPM decoupling.
30. **mqmas3qfamspltse2d.c** - Two-pulse MQMAS with a 3Q phase cycle, a FAM second pulse, a split t1 and a selective echo, with SPINAL or TPPM decoupling.
31. **mqmas3qse2d.c** - Two-pulse MQMAS with a 3Q phase cycle, a selective echo, with SPINAL or TPPM decoupling.
32. **mqmas3qspltse2d.c** - Two-pulse MQMAS with a 3Q phase cycle, split t1, a selective echo, with SPINAL or TPPM decoupling.
33. **mqmas3qzf2d.c** - Z-filtered MQMAS with a 3Q phase cycle, with SPINAL or TPPM decoupling.
34. **mqmas5qzf2d.c** - Z-filtered MQMAS with a 5Q phase cycle, with SPINAL or TPPM decoupling.
35. **mqmas7qzf2d.c** - Z-filtered MQMAS with a 7Q phase cycle, with SPINAL or TPPM decoupling.



36. **mqmas9qzf2d.c** - Z-filtered MQMAS with a 9Q phase cycle, with SPINAL or TPPM decoupling.
37. **mrev8.c** - "X" acquisition with interleaved MREV8, nonquadrature phase cycle.
38. **mrev8q.c** - "X" acquisition with interleaved MREV8, quadrature phase cycle.
39. **onepul.c** - One-pulse preparation, with SPINAL or TPPM decoupling.
40. **onepuldfs.c** - A onepulse experiment on "X" with a double frequency sweep preparation pulse for enhancement of sensitivity through population transfer, with SPINAL and TPPM decoupling.
41. **onepuldpth.c** - Direct polarization of "X" with a DEPTH background filter with TPPM or SPINAL decoupling.
42. **onepultoss.c** - "X" sideband suppression using 4-pulse TOSS one-pulse preparation, with TPPM or SPINAL decoupling.
43. **phtran.c** - Output a phase detected pulse through the directional couplers for phase transient measurement.
44. **pisema2d.c** - A sequence to correlate "X" chemical shift with the X-H dipolar interaction in the rotating frame.
45. **presto1cp.c** - A selective "X" to "H" CP using PRESTO1, R1825 on "H", with SPINAL or TPPM decoupling.
46. **presto2cp.c** - A selective "X" to "H" CP using PRESTO2, R1825 on "H", with SPINAL or TPPM decoupling.
47. **presto3cp.c** - A selective "X" to "H" CP using PRESTO3, R1825 on "H", with SPINAL or TPPM decoupling.
48. **qcpmg1d.c** - A two-pulse solid or "quadrupole" echo with CPMG interleaved acquisition and a choice of SPINAL or TPPM decoupling.
49. **r14inad2d.c** - 1Q-2Q "X" correlation using R14 mixing, with TPPM or SPINAL decoupling.
50. **r2inv1d.c** - A selective inversion on "X" using a hard 90 and a soft 180 after a ramped CP preparation, a rotor-synchronized mixing period and an "X" detection pulse, with TPPM or SPINAL decoupling, separate TPPM or SPINAL decoupling levels during mixing and acquisition.
51. **redor1onepul.c** - REDOR with alternating pi pulses on the "X" and "Y" channels with one-pulse preparation, with TPPM or SPINAL decoupling.
52. **redor1tanccp.c** - REDOR with alternating pi pulses on the "X" and "Y" channels with one-pulse preparation, with TPPM or SPINAL decoupling.
53. **redor2onepul.c** - REDOR with pi pulses on the Y channel and a single refocusing pulse on the X channel, with ramped CP preparation, with TPPM or SPINAL decoupling.
54. **redor2tanccp.c** - REDOR with pi pulses on the "Y" channel and a single refocusing pulse on the "X" channel, with ramped CP preparation, with TPPM or SPINAL decoupling.
55. **repdfs.c** - A repetitive onepulse experiment on "X" with a double frequency sweep preparation pulse for enhancement of sensitivity through population transfer, with SPINAL and TPPM decoupling. Obtains additional s/n on subsequent slices because DFS does not saturate the satellite transitions.
56. **spc5inad2d.c** - 1Q-2Q "X" correlation using SPC5 mixing, with TPPM or SPINAL decoupling.

57. **ssecho1d.c** - A two-pulse spin echo sequence with a 0,90 phase cycle for quadrupole nuclei such as  $^2\text{H}$ , with SPINAL or TPPM decoupling.
58. **stmas2d.c** - Two-pulse STMAS, with SPINAL or TPPM decoupling.
59. **stmasdqfse2d.c** - Four-pulse STMAS with a selective echo and a double quantum filter, with SPINAL or TPPM decoupling.
60. **stmasdqfspltse2d.c** - Four-pulse STMAS with a selective echo, a double quantum filter and a split t1, with SPINAL or TPPM decoupling.
61. **stmasse2d1.c** - Three-pulse STMAS with a selective echo, with SPINAL or TPPM decoupling.
62. **stmasse2d2.c** - Three-pulse STMAS with a selective echo and a phase cycle to provide a triple quantum filter, with SPINAL or TPPM decoupling.
63. **stmasspltse2d1.c** - Three-pulse STMAS with a selective echo and a split t1, with SPINAL or TPPM decoupling.
64. **stmasspltse2d2.c** - Three-pulse STMAS with a selective echo and a split t1 and a phase cycle to provide a triple quantum filter, with SPINAL or TPPM decoupling.
65. **stmaszf2d.c** - Two-pulse STMAS with a Z-filter, with SPINAL or TPPM decoupling.
66. **swwhh4.c** - "X" acquisition with interleaved semi-windowless WaHuHa, non-quadrature phase cycle.
67. **tancp2drad.c** - "X" 2D with constant, linear or tangent CP preparation, with "X" RAD mixing, with TPPM or SPINAL decoupling.
68. **tancp2dspc5.c** - "X" 2D with constant, linear or tangent CP preparation, with "X" SPC5 mixing, with TPPM or SPINAL decoupling.
69. **tanpechocpmg1d.c** - Constant, linear or tangent CP between "H" and "X" followed by a Hahn echo with CPMG interleaved acquisition and a choice of SPINAL or TPPM decoupling.
70. **tancpht1.c** - "H"  $T_1$  measurement with constant, linear or tangent CP preparation, with TPPM or SPINAL decoupling.
71. **tancpxblew.c** - "X" constant, linear or tangent CP, with TPPM or BLEW24 decoupling.
72. **tancpx.c** - "X" constant, linear or tangent (ramped) CP, with TPPM or SPINAL decoupling.
73. **tancpxdumbo.c** - "X" constant, linear or tangent CP preparation with DUMBO decoupling during acquisition.
74. **tancpxecho.c** - "X" Hahn echo with constant, linear or tangent CP preparation, with TPPM or SPINAL decoupling.
75. **tancpxflip.c** - "X" 90-degree pulse measurement with constant, linear or tangent CP, with TPPM or SPINAL decoupling.
76. **tancpxfslg.c** - "X" constant, linear or tangent CP preparation with FSLG decoupling during acquisition.
77. **tancpxidref.c** - "X" interrupted decoupling with constant, linear or tangent CP, with TPPM or SPINAL decoupling.
78. **tancpxpmlg.c** - "X" constant, linear or tangent CP preparation with PMLG decoupling during acquisition.
79. **tancpxt1rho.c** - "X"  $T_{1\rho}$  measurement with constant, linear or tangent (ramped) CP, with TPPM or SPINAL decoupling.

80. **tanepxtoss.c** - "X" sideband suppression using 4-pulse TOSS with constant, linear or tangent (ramped) CP, with TPPM or SPINAL decoupling.
81. **tunerp.c** - Pulse directional-coupler tuning.
82. **twopul.c** - "X" Hahn echo with one-pulse preparation.
83. **wdumbo1d.c** - A 1D acquisition on "X" with windowed DUMBO.
84. **wdumbot1d.c** - A 1D acquisition on "X" with windowed DUMBO, using tilt pulses around the windows, wDUMBOt.
85. **wisetanep2d.c** - 2D correlation between the "X" chemical shift and the "H" wideline spectrum using constant, linear or tangent-ramped cross polarization (CP) between "H" and "X" with a choice of SPINAL or TPPM decoupling.
86. **wpmlg1d.c** - A 1D acquisition on "X" with windowed PMLG,
87. **wpmlg2d.c** - 2D homonuclear correlation with PMLG in F1, a spin diffusion mixing period and quadrature, windowed PMLG (wPMLG) for multiple-pulse acquisition in F2.
88. **xmx.c** - "X" acquisition with interleaved, alternating X and -X pulses, for phase-transient measurement.
89. **xx.c** - "X" acquisition with interleaved X pulses, for pulse-width measurement.