The knownpulsardemod DSO and SFTs – March 2002 LSC Update

Gregory Mendell

LIGO Hanford Observatory

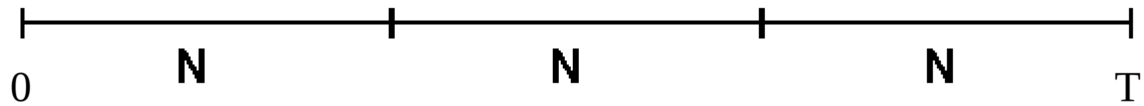
LIGO-G020052-00-W

The knownpulsardemod DSO

- Runs under LDAS as a Dynamic Shared Object. Code is in UWM LALWrapper CVS repository.
- Generates Short-time Fourier Transforms (SFTs).
- Can input SFTs into the LALDemod function to generate the Demodulated Fourier Transform (DeFT) for one input sky position, frequency, and set of spindown parameters.
- Writes statistics to the SIGNAL_DPERIOD database table.

The DeFT Algorithm

Schutz & Papa gr-qc/9905018; Williams and Schutz gr-qc/9912029;
Berukoff and Papa LAL Pulsar Package Documentation



Break T into M segments with N points each:

$$X_b = \sum_{\alpha=0}^{M-1} \sum_{j=0}^{N-1} x_{\alpha j} A_\alpha e^{-2\pi i \Phi_{\alpha j b}}$$

Inverse DFT can be substituted:

$$x_{\alpha j} = \frac{1}{N} \sum_{k=0}^{N-1} X_{\alpha k}^{SFT} e^{2\pi i j k / N}$$

After substituting…

$$X_b = \sum_{\alpha=0}^{M-1} A_\alpha Q_{\alpha b} \sum_{k=0}^{N-1} X_{\alpha k}^{SFT} P_{\alpha k b}$$

- Algorithm is coherent.
- Linearly expand phase about midpoint of each segment (assumes f ~ constant during each segment.); P is peaked and can sum over only ~ 16 values of k.
- Need to run algorithm for each f (unlike FFT); but algorithm is easy to code to run on a parallel cluster. Data for long T can fit into the memory of one processor.

Taylor expand the phase

$$\Phi_{\alpha jb} = \Phi_{\alpha,1/2,b} + f_{\alpha,1/2,b}(t_{\alpha j} - t_{\alpha,1/2})$$

$$P_{\alpha kb} = \frac{\sin u_{\alpha kb}}{u_{\alpha kb}} - i\frac{1-\cos u_{\alpha kb}}{u_{\alpha kb}}$$

$$Q_{\alpha b} = e^{iv_{\alpha b}}$$

$$u_{\alpha kb} = 2\pi\left(\frac{T}{M} f_{\alpha,1/2,b} - k\right)$$

$$v_{\alpha b} = -2\pi\left(\Phi_{\alpha,1/2,b} - \frac{T}{2M} f_{\alpha,1/2,b}\right)$$

SFTs

- The SFT Specification is in the DCC: LIGO-T020043-00-W.
- SFTs are used to generate DeFTs.
- SFTs are FFTs of short-time baseline time series.
- Can ignore Doppler effect for

$$T_{SFT} \leq 5.5 \times 10^{3} \sqrt{\frac{300\,Hz}{f_0}}\ \mathrm{sec}.$$

Schutz & Papa gr-qc/9905018

- For f_0 = 2000 Hz, T_{SFT} < 2130 s; choose 2048 s.

Input Time Series

- The "gravity-wave" channel is input (e.g., H2:LSC-AS_Q by the LDAS frameAPI for every T_{SFT} = 2048 seconds of data.
- The data is resampled to 4096 Hz by the dataconAPI. This includes anti-alias filtering.
- Time delays introduces by filtering are handled by bringing in extra data at the ends of the time series. The time segment starting at the GPS time wanted is then sliced out of the resampled data.

Data Quality and Dropout

- Clean locks are used to generate a quality channel. Poor quality data is "padded" (replaced) with the mean of the good quality data. The percent of the data padded is stored in the SFT history structure.
- Data dropout code is not yet working. SFTs will be missing for drop outs during E7.

Output SFTs

- Computed using LALForwardRealFFT.
- Frequency bins range from 0 Hz to 2048 Hz (the Nyquist Frequency).
- Frequency Step Size = $1/T_{SFT}$ = (1/2048) Hz.
- Normalized by $\Delta t / \mathrm{sqrt}(T_{SFT})$; not calibrated.
- SFTs are output in frame format as COMPLEX8 data in the proc structure. File size = 32+ MB.
- Example: H-P_NORMAL1001_SFT_H2_693644217-2048.gwf

FrDump Example

[gmendell@vulcan SearchCodeOut]$ FrDump -i H2-SFT_TEST1_4-600000000-1.gwf -d 5

...

History records:

...

Processed Data:

Proc: sft_output sampleRate=-1 fShift=0.0000e+00 comment:multiDimData to ProcData

Vector:data ndata=9 nDim=1 unitY= s^1/2 count unitX=hz startX=0.00e+00 dx=1.28e+02

Data(CD) (7.161711e-03,0.000000e+00) (7.879787e-03,1.053996e-03) ...

SFT History Structure Meta Data


```
<ilwd name='LDAS_History' size='9'>
    <ilwd name='percent_pad'>
        <real_4 units='percent'>0.0000000e+00</real_4>
    </ilwd>
    <ilwd name='max_power'>
        <real_4 units='power'>7.8124991e-03</real_4>
    </ilwd>
    <ilwd name='freq_pwmax'>
        <real_4 units='hz'>3.8400000e+02</real_4>
    </ilwd>
    <ilwd name='power_mean'>
        <real_4 units='power'>8.6805545e-04</real_4>
    </ilwd>
    <ilwd name='power_stddev'>
        <real_4 units='power'>2.4552315e-03</real_4>
    </ilwd>
    <ilwd name='startSec'>
        <int_4s units='s'>600000000</int_4s>
    </ilwd> <ilwd name='startNan'>
        <int_4s units='ns'>0</int_4s>
    </ilwd>
    <ilwd name='sample_rate'>
        <real_4 units='hz'>2.0480000e+03</real_4>
    </ilwd>
    <ilwd name='ndata_input'>
        <int_4s units=' '>16</int_4s>
    </ilwd> </ilwd>
```

Known Pulsar Demod MDC

- Held November 27-30 at LHO.
- In DCC: LIGO-T020014-00-W
- Primarly Tested SFT generation.
- MDC scripts and documentation are in UWM mdc CVS repository.

Example Test

TEST 2a Correctness of SFT output

Purpose: Test that the SFTs output by the KPD DSO are indeed the DFT of the input data for input data with known results.

Tester: ______________. Date & Time: __________. Tester Location: ___________.

Job Site: _______________________. Job Database: __________________________.

Job Channel: ___________________. Job Log File: ____________________________.

Instructions: (See the "How to run the test scripts" section if you need help.)

Use RunJob.tclsh to run the jobs below, perform the task indicated, and record the results.

1. Impulse tests. These test run on KPDTEST-ImpulseN32I16-600000000-1.gwf, which contains 32 data points sampled at 32 Hz, with an impulse in the 16th data point (index = 15).

. a. Run kpdImpulseTest.job. The output will be an xml file. Ftp the result to the KPD MDC output URL. Append test.2a.1a to the name. Check that the results agree with that in ASCII_ImpN32I16Output.txt.

LDAS Job #:   Pass/Fail

E7 Progress

- Loop scripts are running at the sites to generate SFTs for L1, H1, and H2.
- Scripts are checked into UWM mdc CVS repository.
- Sample SFTs are available via anonymous ftp. Soon all E7 SFTs will be available.

Goals before S1.

- Update knownpulsardemod DSO to work with latest LAL and LDAS code.
- Understand distribution of SNR and F statistic in Jaranowski, Krolak, and Schutz gr-qc/9804014.
- Understand how to set upper limits.
- Design and run knownpulardemod MDC tests for LALDemod.
- Identify known pulsars, run code, analyze results.
- Other issue are sure to come up.

Interface to the Scientist