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POCKET BEAMFORMER

1. AIM : To Execute Pocket Beamformer Design on FPGA and to get the Pulsar Profile.

2. APPARATUS :

1. **ROACH UNIT : ROACH BOARD with one iADC card.**

2. **PC : To control the ROACH board (192.168.4.68). This PC must have the 'Gulp' and 'Wireshark' utilities and 1 10GBe NIC installed .**

 # Wireshark utility is used to check whether the packets from ROACH are coming are not.

 # Gulp utility is used to capture the packets.

3. **10G Ethernet cable : This is used for high speed data transfer (faster integration).**

4. **Signal generator and its probe : This is used to provide clock signal to ROACH .**

It must be able to provide at least 400MHz RF .

5. **Power cables :**

Each one for a] ROACH b] Signal Generator

6. **SMA to SMA connectors : (minimum 3 Nos)**

This is the Sub Miniature Version A Coaxial RF connector used to provide input signals and clock signal to ROACH.

Adjust the length of those cables depending on the location from where you tap the input signal and clock signal.

7. **100Mbps Ethernet cable : Each one for ROACH and controlling PC.**

8. **Files Required :**

a] .mdl file : This is matlab simulink model of pocket beamformer design.
pobe4a_incoh_2k.mdl

b] .bof file : This file is used to program the FPGA with the beamformer design.
pobe4a_incoh_2k.bof

c] Python Script : Python script is used for initialization and controlling of various software registers in the simulink design at run time.
pobe_incoh_2k.py

d] C programs : Used for Depacketisation of packets captured.

1] file_fast.c : for lab test
2] file_fast_pmon.c : for sky test

3. PROCEDURE :

A] MAKE ALL THE CONNECTIONS AS DIRECTED BELOW.

1. Apply the clock signal to one of the ADC on ROACH from signal generator via sma to sma cable. clk_i of the ROACH is meant for clock input.

- **Set RF : 400MHz and Power:0dbm**
- **Set RF "ON" and Mod "OFF" by pressing appropriate keys.**

2. Apply input signals from antenna.

Go to control room and ask the operator to set the antennas as per your requirements. The information that you have to provide is:

- **Name of the antennas e.g C03, C08. Or S02, E06. (you can choose any two available antennas of same type)**
- **RF : 325 MHz / 610MHz / L band**
- **Baseband IF , ALC status (on/off), Baseband Local Oscillator freq., LO1**
- **GSB settings : Bandwidth : 32Mhz , Number of Channels : 512 , IA - PA ON, GAC add : specify name of the antennas that you use , POST_INT : 2**
- **Name of the source you want to track .e. g. B1133+16 pulsar**

Tap the respective signals using sma to sma cables of proper length either from front panel of Baseband Rack or from backside of the baseband rack (if front panel is faulty).

NOTE : If signals are to be tapped from backside of baseband rack then you need to use 2way power divider so that both GSB system and your design can get signals simultaneously.

Adjust the power level of input signal by monitoring it on the spectrum analyzer.

For adjusting IF power you may take help from Operators in control room. You must get Low Pass Filter response with 32MHz cut off.

Max power : -12dbm minimum power : -21dbm
Avg. Power : -15 to -16 dbm

when the power levels are confirmed to be proper connect the input signal to ADC on ROACH board. The I+ and Q+ connectors on iADC are meant for inputs.

3. Connect 10G cable between PC and one of the 4 CX4 connectors on ROACH.

4. Connect one Ethernet cable to ROACH and another to PC from the Network Switch.

ALL THE HARDWARE CONNECTIONS ARE DONE NOW !!!!!

B] INITIALIZATION & LOADING THE DESIGN IN THE FPGA :

Login to the PC controlling ROACH board and go to the directory where all the scripts are placed.

Run following command : ./ pobe_incoh_2k.py 2

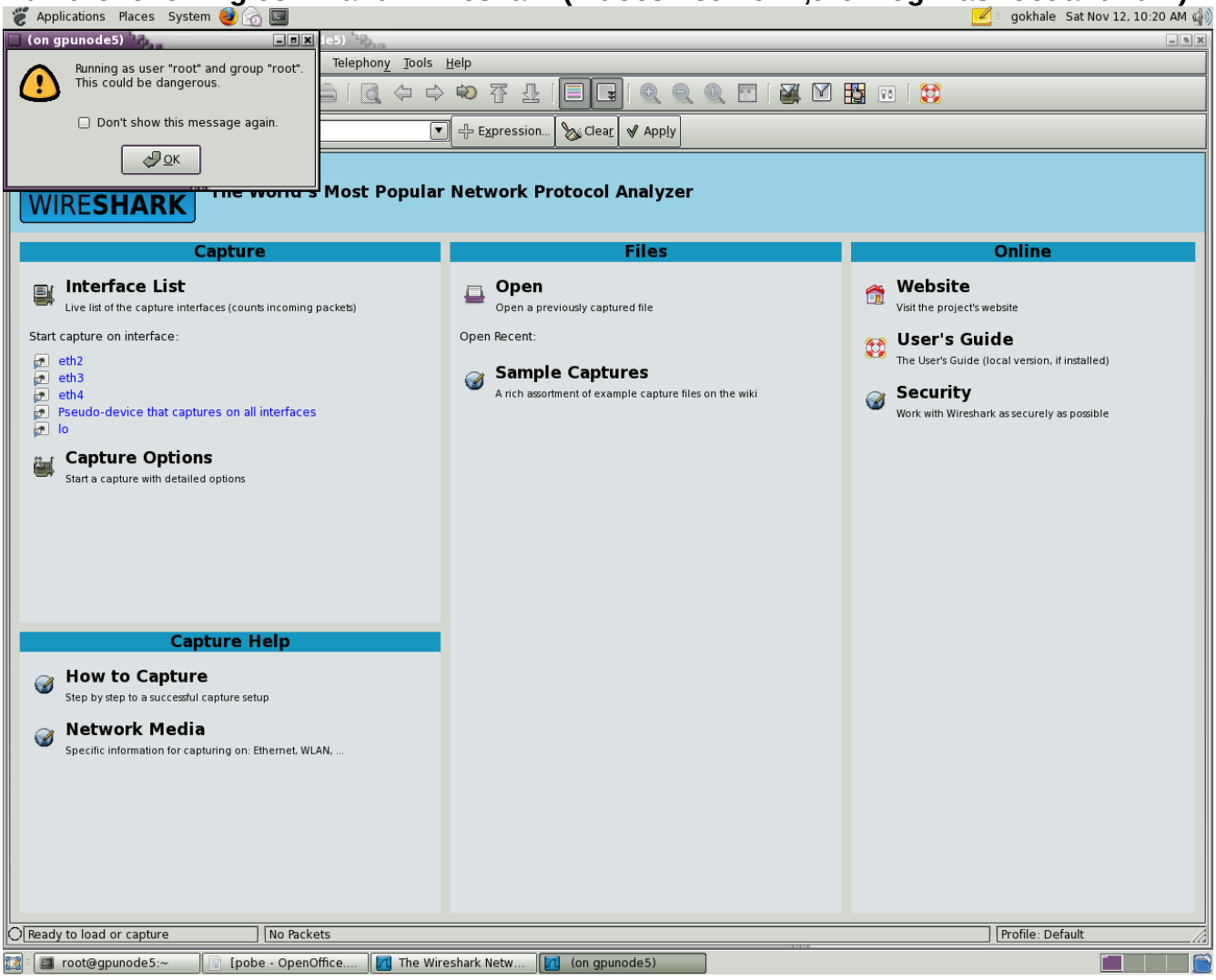
here 2 : 4 antenna beamformer

0 : 2 antenna beamformer of ADC0 inputs

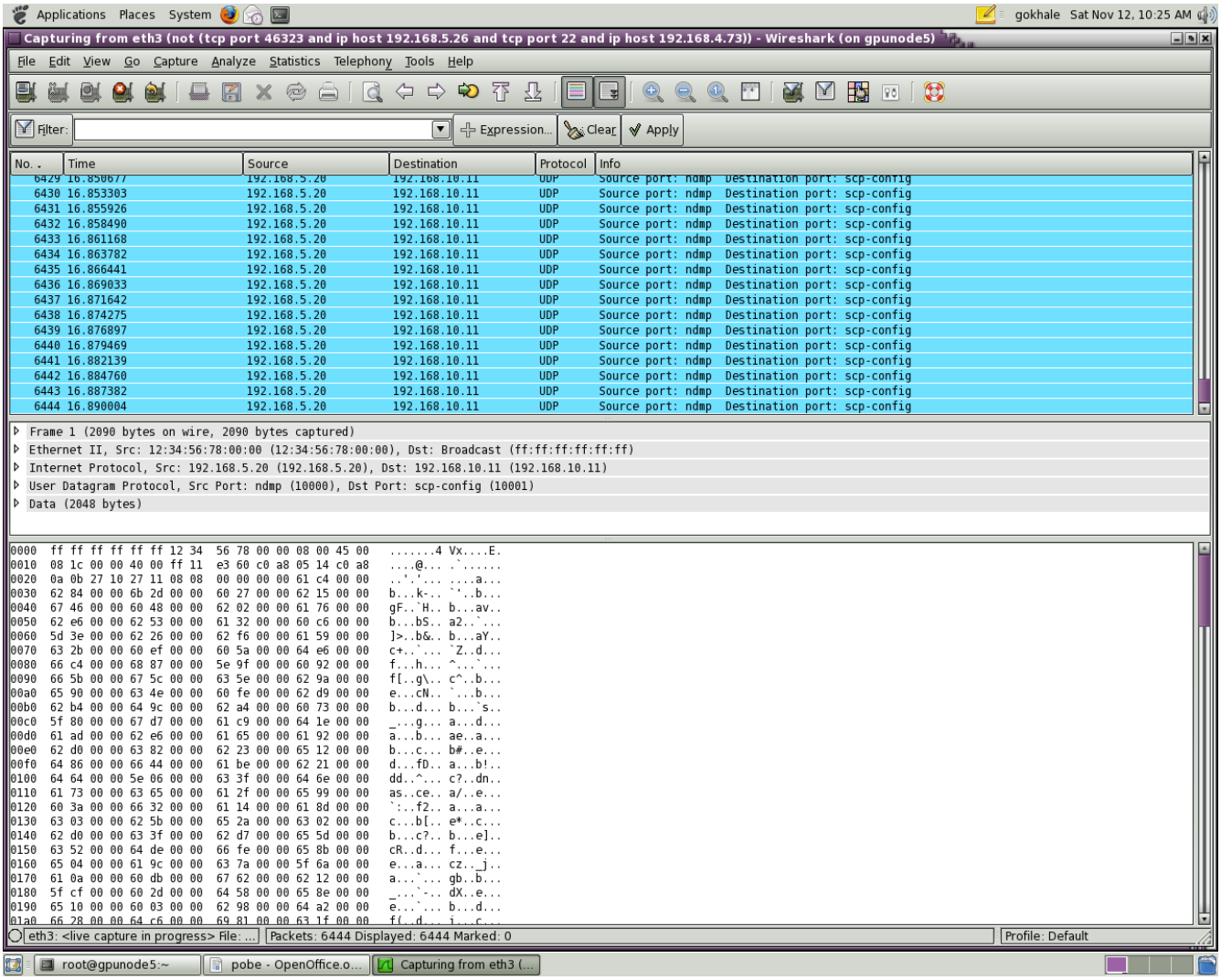
1 : 2antenna beamformer of ADC1 inputs.

C] RUN WIRESHARK PROGRAM :

Run the following command : wireshark (if does not work ,then login as root and run).



- **Click ' OK '**
- **click ' Capture' in menu bar on top of window**
- **click ' interfaces' to check the arrival of packets on desired interface.**
- **To see the packets click ' Start' tab next to desired interface. You will see the following window**



Once you make sure that packets are coming properly, close the window depicted above.

- **click 'interfaces'**
- **click ' stop'**

then close the window.

D] GRABING THE PACKETS ON 10GE LINK USING GULP UTILITY :

If commands do not work , login as root

- **cd /data/Gulp/**

This folder contains gulp.c program. You have to enter the number of packets to be captured on line number 294.After saving changes in gulp.c files, run 'make' command.

- **./gulp -i name of interface > filename.**

e.g. ./gulp -i eth2 > B1133+16_121111

Now packet capturing process is started. Wait for few minutes, to capture packets (say 10min) and then press 'ctrl+c' to stop the capture process.

you may see the following lines.
96773 packets captured
96772 packets received by filter
0 packets dropped by kernel
ring buffer use: 0.1% of 100 MB
Figures may vary depending upon your duration of packet capture.

E] DEPACKETIZATION USING C PROGRAM :

for pulsar test : ./file_fast_pmon.o filename depacketised_data 2048 1024

for lab test : ./file_fast.o filename depacketised_data 2048 1024
filename : captured data
depacketised_data : data obtained after depacketisation
2048 : packet size
1024 : scaling factor

F] PLOTTING THE RESULTS :

1] Using the GNUPLOT :

 # In the tab or terminal in which you depacketised the data, type the following command and press 'enter'
gnuplot

you will see the following lines :
G N U P L O T
Version 4.0 patch level 0

last modified Thu Apr 15 14:44:22 CEST 2004
System: Linux 2.6.18-194.8.1.el5
Copyright (C) 1986 - 1993, 1998, 2004
Thomas Williams, Colin Kelley and many others

This is gnuplot version 4.0. Please refer to the documentation
for command syntax changes. The old syntax will be accepted
throughout the 4.0 series, but all save files use the new syntax.

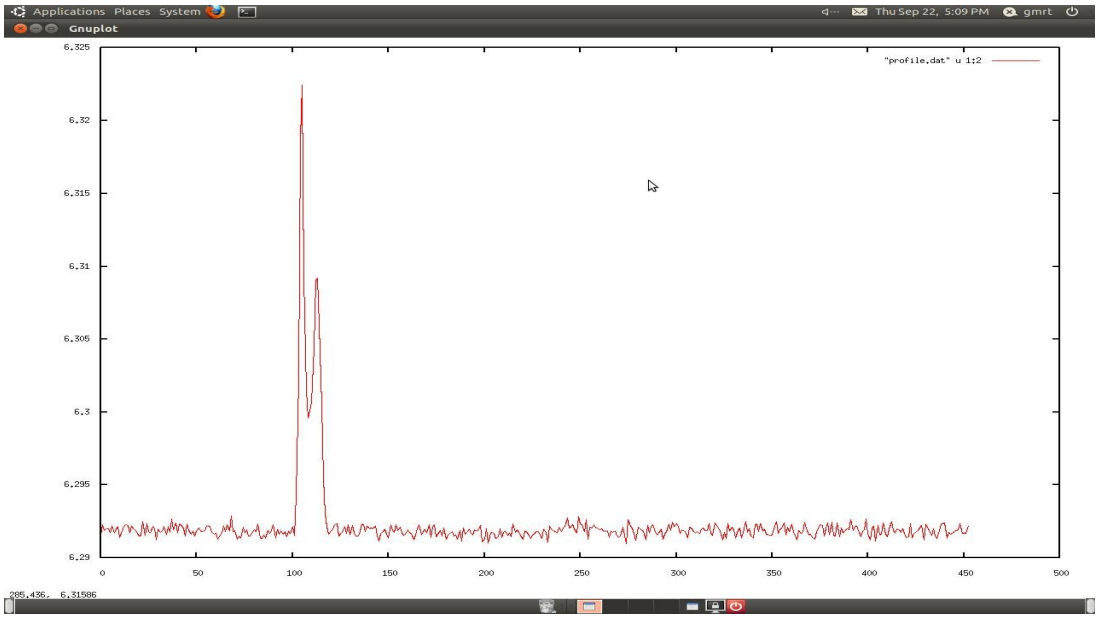
Type `help` to access the on-line reference manual.
The gnuplot FAQ is available from
http://www.gnuplot.info/faq/

Send comments and requests for help to
<gnuplot-info@lists.sourceforge.net>
Send bugs, suggestions and mods to
<gnuplot-bugs@lists.sourceforge.net>

Terminal type set to 'x11'

gnuplot> **here you enter the following commands to plot the results.**

> plot “depacketised_data” w l (press 'enter'). Save the plot. See the plot given below



2. USING PMON (Pulsar MONitor) :

NOTE : DO NOT TRY THIS WHENEVER YOU ARE USING CONTROL ROOM MACHINE for PMON whenever GMRT OBSERVATIONS AND/OR SOFTWARE TESTING RELATED WORKS ARE GOING ON. IT MIGHT CREATE PROBLEM.

Step 1 : For using PMON utility, you need to first install PMON software in your machine or you can login to machine in which PMON is already installed.
In GMRT, PMON is installed on machines kept in control room.

a] open a terminal and type following command :
ssh -X gsbuser@gsbm3
b] enter the password :
gmrt.123

Step 2 : Create your own directory in the below mentioned area to store your data.

a] cd /mnt/b/gsbuser/
b] mkdir dir_name In this command you replace 'dir_name' with the the name that you may like.

Step 3 : To use PMON the below mentioned 3 files must be present in your current directory.
i] pmon.in
ii] raw.hdr
iii] file that contains the actual data that you want to dedisperse
e.g. PulsarB1133+16.raw

pmon.in : This file must be edited according to your specifications.
a] For editing this file type following command and press 'enter':
vi pmon.in
b] This file is divided into two parts using ':'. To left of which you need to enter specifications. The R.H.S part just describes what you have to enter. Don't modify this R.H.S part.
e.g. : vi pmon.in you may see the following lines.

2.62144,591.0,200.0,+1 : Sample Interval (millisecond), Center Freq (MHz), BW (MHz) & Sideband flag (+1/-1).
512,2,90 : Total # of Freq Channels, Start & Stop Freq Ch #s to use.
512 : Reference Ch # for De-dispersion.
1.0,0.1 : Time Interval per plot, Time Interval between updates (both in secs).
2.5 : Time Interval for Fold/Spectral updates (in secs).

0,0,0.0 : Start Block # , Total # of Blocks and fraction of blocks to be skipped (give 0,0,0.0 for doing entire file).
B1133+16 : Source name with or without J/j/B/b prefixed.(This gets ignored if name passed at command line)
60,12,12 : N_Span (min), N_Coeff, Max_HA for the Polynomial coefficients in the polyco.dat.
-1 : DM (pc/cm^3) for de-dispersion: For acquiring DM using Catalogue give a # < 0.0
-1 : period (millisec) for folding: For acquiring period using Catalogue give a # <= 0.0
1.0,1.0 : Expansion factor for time plot, Expansion factor for folded profile.
0.0,0.0 : Phase offset for markers & Initial Phase Offset for folding (in units of true sample).
0.0,0.0 : Zoom-in: Start & Stop X axis Fraction for profile/spectrum plots(use 0,0 for full range).
0 : Domain of Folding : Time(0) / Freq(1).
4,4 : # of Polarization added in the GAC data, # of integration in the DSP.
2 : # of Bad Bands: If its 'N' then list the start & stop chan # for each band in next N lines.
1,4 : Start Chan # , Stop Chan # for Bad Band 1.
253,256 : Start Chan # , Stop Chan # for Bad Band 2.

Save and exit after making appropriate changes.

B] raw.hdr :

This file must be edited according to your timing specifications.
a] For editing this file type the following command :
vi raw.hdr This file contains date and time of your data recording.

#Start time and date
IST Time: 11:50:25.178647040 - > here enter time as precise as possible.
Date: 21:09:2011 -> here enter date
#Start ACQ SEQ NO = 12621 -> keep as it is.

Save and exit after making appropriate changes.

C] File containing data to be dedispersed :

Copy your file containing data to dedispersed e.g PulsarB1133+16.raw in your directory.

Case i] if your original data file is present in same machine where pmon is installed use following command :

mv /dir1/dir2/filename /mnt/b/gsbuser/yourdir/filename
in the above command enter the actual directories and file names

case ii] if your original data file is present in other machine use following command :

scp username@ipaddress :/dir1/dir2/filename /mnt/b/gsbuser/yourdir/filename

Step 4 : Now type the command ;

pmon -f filename -s sourcename

e.g. pmon -f PulsarB1133+16.raw -s B1133+16

You will see the following result.

```
      Reading data from file
file name = `c2'
stokes_sel = 0

Mode selected for reading data ip_mode = `f'
ts = 2.621440, f0 = 591.000000, BW = 200.000000, i_side_band = 1
NCH=512,NCH1=2,NCH2=90
ref_ch = 512
time_plot_chart = 1.000000 sec, time_update_chart = 0.100000 sec
time_update_main = 2.500000 sec
iblk1=0,nblks=0,skip_frac=0.000000
Source name = B1133+16
N_Span=60, N_Coeff=12, MaxHA=12
samp_fac = 1.000000, binfac=1.000000
noff1=0.000000, noff2=0.000000
start_val=0.000000, stop_val=0.000000
ioption=0
n_pols=4 n_int=4
Total number of bad channels to be flagged = 8
The bad channels are: 1 2 3 4 253 254 255 256

============================================================
                    YYYY MM DD HH mm SS.ss
============================================================
IST of the epoch of Observation : 2011 11 10 12 30 25.178647040
UTC of the epoch Of Observation : 2011 11 10  7  0 25.178647040
MJD of the epoch of Observation : 55875.29195808619
============================================================

J Name of the Source given is = J1136+1551

polyco.dat being generated using Gen_polycos(0) for start MJD = 55874.50 and end
MJD = 55876.50

The entire polyco file has been successfully loaded into polyco_Array.
Total No of Pset loaded is N_PSet= 72
The Value of period as obtained for the Observation epoch using polycos =
1187.81667976239919 (millisec)

Generating the value of DM for source J1136+1551 using the polyco file
The Value of DM as obtained from catalogue = 4.863999844 (pc/cm^3)
```

NCH1=2, NCH2=90, n_pols=4, n_int=4, product=1424
Data Type = 2
  nsamp_plot_chart = 381, nsamp_plot   = 381
nsamp_update_chart = 38, nsamp_update = 38
      nbytes_read = 1953792, nbytes_read_max = 134217728

narray_fft = 2048
Number of time samples per block (full and reduced) narray_full = 1908, narray = 1908
NSAMP_PLOT + NSAMP_UPDATE SHOULD BE < 1/4 OF THE ABOVE!

# of points per plot = 381, # of points between updates = 38
start block # iblk1 = 0, total # of blocks for analysis = 0

Opened file 'bandshape.dat' to save initial, final and mean bshapes ...

Opened file 'pmon.log' to save log information.
DM = 4.864000, f0 = 591.000000, BW = 200.000000, ts = 2.621440, NCH = 512, NCH1 = 2, NCH2 = 90
Doing UPPER sideband ananlysis
There are '8' bad channels
Allocated memory to iBuf
Allocated memory to buf
Allocated memory to temp_iBUf

GPS Maski = fffe

Doing current DM = 4.864000 pc/cc
Calculating dispesion delays...
Bandwidth per channel = 390.625000 (KHz)
Reference channel no. = 512
Total delay over entire BW   = 22.268475 (msec), 10
Min., Max. delay over one channel = 0.031879 0.031879(msec)
Sampling invterval   = 2.621440 (msec)

Folding for variable P using 'polyco.dat'
true, reduced nbins : nbins1=453, nbins=453
Folding phase offset in samples (true, reduced): 0.000000 0.000000

start and stop frequencies of display are istart*del_f = 0.000000 Hz, istop*del_f = 0.000000 Hz
xmin_1=0.000000, xmax_1=381.000000, ymin_1=-0.500000, ymax_1=14.500000

 Graphics device/type (? to see list, default /xwindow) :
        NOTE : after ' : ' type following command and press 'enter'
                /xs
        and you can see the profile in PGPLOT window which will consist of 4 subplots;

1. Chart record of dedispersed data -- time vs signal amplitude.

2. Bandshape -- frequency vs bandshape amplitude.

3. Folded profile (cumulative)v -- pulse phase vs profile amplitude.

4. Folded profile (current) -- pulse phase vs profile amplitude.