# SOP for testing 4/8 antenna PACKETIZED CORRELATOR.

By : Sandeep C. Chaudhari & Irappa M. Halagali .
VERSION : 3 Dated : 05/07/2013

Packetized correlator is a general purpose re-configurable digital backend for radio astronomy applications on CASPER hardware ROACH-Vertex5 boards using XAUI or 10Gbe designs. This SOP is for XAUI designs.

## I. Power ON and instrument settings :

(a) Power on Distribution boards , AC distribution boards in the RACK
*(verify : PC , Ethernet switches & ROACH Units are powered ON).*
(b) Now Switch ON the instruments and do the following settings -
(i) Signal generator settings as CLOCK to F engine ROACH boards : Freq = 800MHz , Power = 0dbm, Set “Mod to OFF and RF to ON”
(ii) Connect the PPS signal available in the rack to all Sync input of F engine ROACH boards.
(c) Power “ON” the ROACH boards by pressing the switch at front panel. All Roach boards will boot through NFS (Network File System) on control PC {192.168.4.71}.

## II. Interconnections :

1. Connect the clock & pps signals available at top of the rack to all ROACH units clk_i and Sync inputs of iADC respectively.
2. Either connect 32MHz or Broadband analog signals or Noise Source through 200 MHz LPF, Total Power over BW between -14dbm to -17dbm to iADC's inputs.

## III. XAUI BASED 4/8 Antenna packetized correlator setup :

**GMRT Digital Backend specifications :**

| | | |
|---|---|---|
| Number of stations | : | 4/8 dual pol. |
| Maximum instantaneous Bandwidth | : | 400 MHz |
| Number of spectral channels | : | 512 |
| Number of input polarizations | : | 2 |
| Full stokes capability | : | yes |
| Dump time | : | minimum 128 ms |
| Coarse and Fine delay correction range | : | +/- 128 us. |
| Base integration | : | 1.00007936 seconds. |

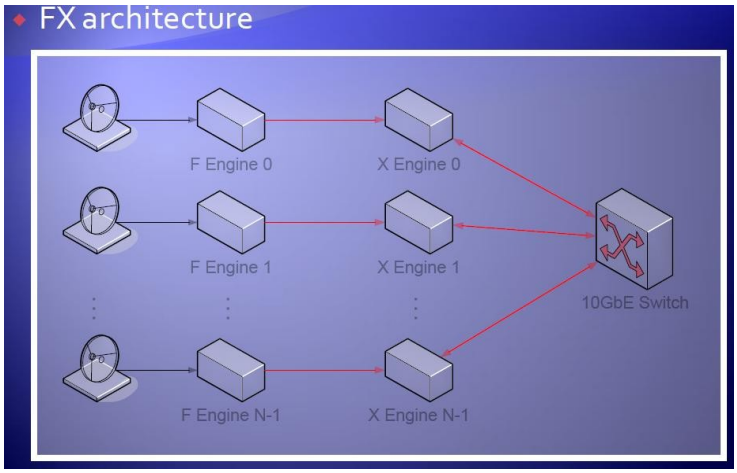
| | 4 antenna | 8 antenna |
|---|---|---|
| Total ROACH boards required | 8 | 16 |
| F engine Roach boards | 4 | 8 |
| X engine Roach boards | 4 | 8 |

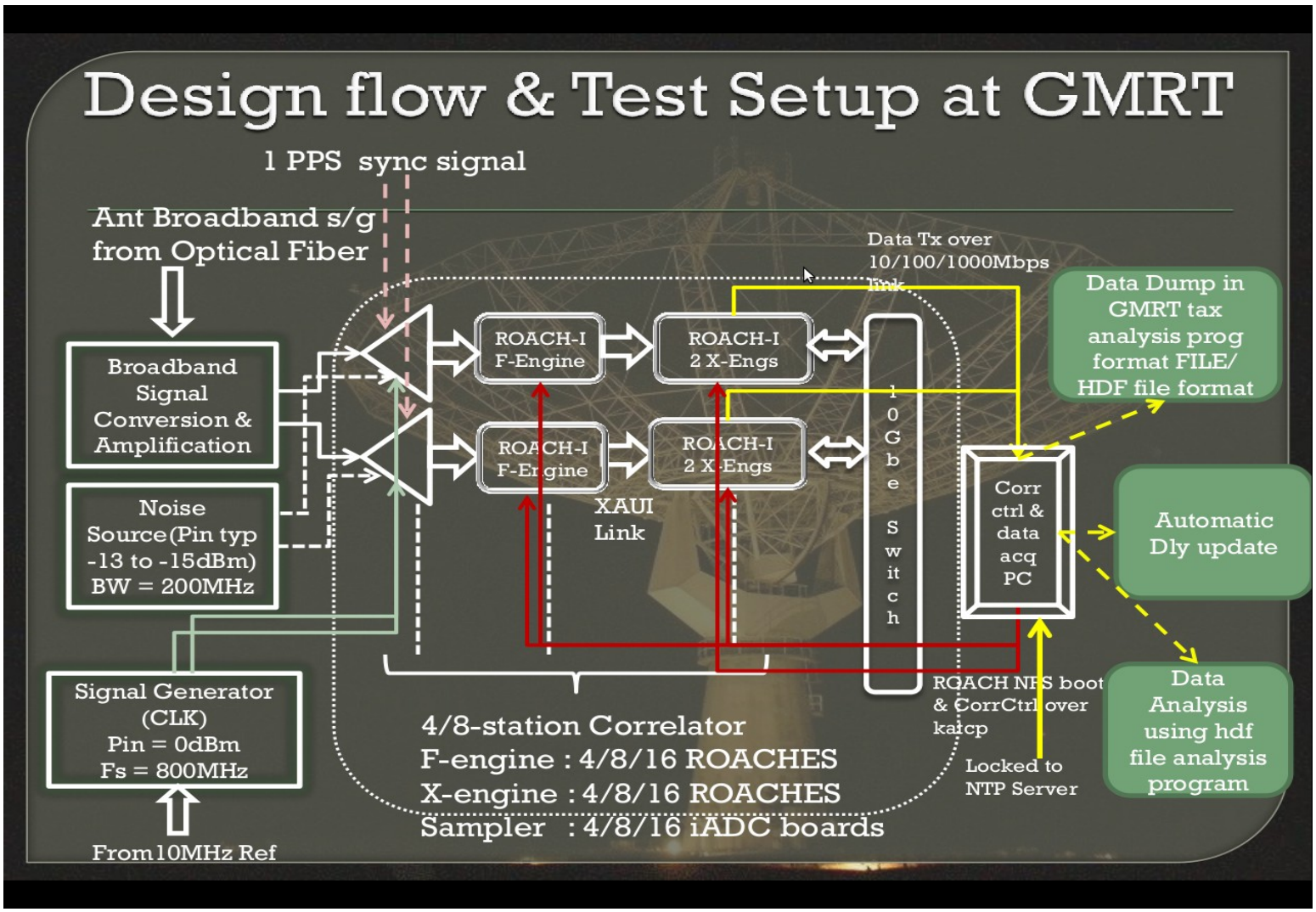
**Note : For complete packetized correlator setup refer the following diagrams.**

**XAUI Packetized Correlator Connections :-**

1. $n^{th}$ F-eng CX-4 port-0 => $n^{th}$ X-eng CX-4 port-0.
2. All X-eng CX-4 port-3 => 10Gbe Switch.
3. All ROACH board's eth-0 port connected to 1Gbps switch.
4. 1Gbps to the control PC's eth-1 port in a private network.

**Control PC eth-0 IP : 192.168.4.71**
**Control PC eth-1 IP : 192.168.100.1 (Private Network)**
**ROACH Board eth-0 IP : 192.168.100.<Last 2 MAC No.>**



# IV. Initialization & Data acquisition :

Login to control PC : ssh -X gmrt@192.168.4.71
Password : gmrttifr
> sudo konsole

This opens new console. Now start working in newly opened console. Press shift+ctrl+N to open more konsoles.

**Note : 1. For all scripts -h command line option will show options associated with that script.**

**2. Go to working Directory in Each KONSOLE TAB**

**Working Directories :**

**a.** for 4 antenna
**/home/gmrt/Packetized_Corr/XAUI_Corr/4Ant_Corr/Ant_Tests/ or**
**/home/gmrt/Packetized_Corr/XAUI_Corr/4Ant_Corr/Basic_Test/ (for Noise Source tests)**

b. for 8 antenna
**/home/gmrt/Packetized_Corr/XAUI_Corr/8Ant_Corr/Ant_Tests/ or**
**/home/gmrt/Packetized_Corr/XAUI_Corr/8Ant_Corr/Basic_Test/ (for Noise Source tests)**

**3. Determining integration number in configure file.**

**For base integration of 1.00007936 following integration number should be entered in the configure file in multiple of below mentioned number.**

**1K point FFT ===> n = 6104.**
**4K point FFT ===> n = 1526.**

**Multiple of n should be entered in configure file so as to get integration in multiple of base integration in acc_len field as acc_len = <desired n>.**

KONSOLE TAB-1 : { To issue some basic commands from ipython }

> ipython

```
In [1]: import corr,struct,time,sys,spead,numpy,pylab,katsdisp,h5py,signal
In [2]: dh=katsdisp.KATData()
In [3]: dh.start_spead_receiver()
In [4]: c=corr.corr_functions.Correlator(connect=True,
config_file='config_4ant', log_handler=None, log_level=20)  # for 4 ant...
          OR
In [4]: c=corr.corr_functions.Correlator(connect=True, config_file='config_8ant'
, log_handler=None, log_level=20)  # for 8 ant.....
In [5]: c.deprog_all()
```

(This Step is required if we want to test 4-antenna correlator in a 8-antenna setup)

KONSOLE TAB-2 : { For Configuring the system }

```
> corr_rx.py -a config_4ant          #for 4 antenna
> corr_rx.py -a config_8ant          #for 8 antenna
```

```
Parsing config file...INFO:corrsys:Configuration file config_4ant parsed ok.
 done.
Initialising SPEAD transports for inter data...
Data reception on port 7148

Sending Signal Display data to 127.0.0.1:7149.
Storing to file 1346318311.91.corr.h5
starting target with kwargs  {'acc_scale': False, 'sd_port': 7149, 'sd_ip': '127.0.0.1',
'filename': '1346318311.91.corr.h5'}
WARNING: This function is not yet tested. YMMV.
INFO:rx:Data reception on port 7148.
INFO:rx:Sending Signal Display data to 127.0.0.1:7149.
INFO:rx:Starting file 1346318311.91.corr.h5.
```

Note : Remove the latest h5 file generated by corr_rx.py in the same area without deleting corresponding file with .raw extension.

KONSOLE TAB-3 : { For initializing the system }

> corr_init.py config_4ant #for 4 antenna
> corr_init.py config_8ant #for 8 antenna

```
Connecting... done                  # messages for 4 antenna initialization.
======================
Initial configuration:
======================
 Clearing the FPGAs... done.
 Programming the Fengines with r_128w_512_11_r370_mod3_16_2012_Jul_04_2019.bof and the Xengines
with r_1f_2x_4a_r340c_2011_Feb_11_1454.bof... done.

 Pausing 10GbE data exchange... Pausing Xengs... done.
 Syncing the F engines... Armed. Expect trigg at 14:55:40 local (09:25:40 UTC). SPEAD packet
sent.
 Checking F engine clocks... ok
 Setting the board indices... done
 Setting the FFT shift schedule to 0x7FF... done
 Configuring EQ... done
 Configuring the 10GbE cores... done
 Waiting 13.6 seconds for ARP to complete... done
 Starting 10GbE data exchange... X engines re-enabled.
 Flushing loopback muxs... done.
==================================
Verifying correct data exchange...
==================================
 Wait 2 seconds for system to stabilise... done
 Resetting error counters... done
 Checking that all XAUI links are working... ok
 Checking that the same timestamp F engine data is arriving at all X boards within a sync
period... ok
 Checking that FPGAs are sending 10GbE packets... ok
 Checking that all X engine FPGAs are receiving 10GbE packets... ok
 Waiting for loopback muxes to sync... ok
 Checking that all X engines are receiving all their packets... ok
 Setting the number of accumulations to 1562368 (2.000 seconds) and syncing VACCs... done
 Checking vector accumulators... Waiting for an integration to finish... done. Checking... ok
 Sending SPEAD metatdata and data descriptors to 127.0.0.1:7148... done
 Configuring output to 192.168.100.1:7148... skipped.
 Starting transmission of data... done
 Resetting error counters... done
```

```
Enabling KITT... done
```

KONSOLE TAB-4 : { For running the data/packet transmitting script on X-engines to dump data in h5 format in the current directory }

A spead packet transmitting script invoked on all x-eng ROACH boards by this shell script.

Note : Dump file will be in the current directory with extension " .raw "

<corr_rx_script_start_time_since_epoch.h5.raw>

#for 4 antenna

> cd /home/gmrt/Packetized_Corr/XAUI_Corr/4Ant_Corr/

> ./roach_TXallstart_lab.sh

```
1346319332.159112223
ssh root@roach030167 corr_tx_spead_inter.py -l 1024 -i 192.168.100.1 -x 2 -s
1346319332.159112223 315
ssh root@roach030116 corr_tx_spead_inter.py -l 1024 -i 192.168.100.1 -x 2 -s
1346319332.159112223 315
ssh root@roach030174 corr_tx_spead_inter.py -l 1024 -i 192.168.100.1 -x 2 -s
1346319332.159112223 325
ssh root@roach040235 corr_tx_spead_inter.py -l 1024 -i 192.168.100.1 -x 2 -s
1346319332.159112223 315
```

#for 8 antenna

> cd /home/gmrt/Packetized_Corr/XAUI_Corr/8Ant_Corr/

> ./roach_TXallstart_lab.sh

**For Stopping the data transmission at any instant of time, run the following shell script, which will kill spead packet tx script on all x-eng ROACH boards.**

#for 4 antenna

> cd /home/gmrt/Packetized_Corr/XAUI_Corr/4Ant_Corr/

> ./roach_TXallstop_lab.sh

```
ssh root@roach030167 pkill -f corr_tx_spead_inter.py
ssh root@roach030116 pkill -f corr_tx_spead_inter.py
ssh root@roach030174 pkill -f corr_tx_spead_inter.py
ssh root@roach040235 pkill -f corr_tx_spead_inter.py
```

#for 8 antenna

> cd /home/gmrt/Packetized_Corr/XAUI_Corr/8Ant_Corr/

> ./roach_TXallstop_lab.sh

## V. Delay UPDATE :

For doing delay update, go to delay_cal_brdbnd/ directory in the existing location. Following changes to be done during antenna testing :

1.Update source.hdr file with corresponding RA & DEC information from one of the online machine (lenyadri/shivneri) as follows :

1.

>ssh observer@lenyadri
>Password: obs@gmrt
>work
>./user0.5
GMRT 1: Enter user ID number

>?40
GMRT 1: Recovered POPS environment from last exit

>gts '3C286'  <or any other source name>
3C286       13h31m08.28s    +30d30'32.9"      12  12
GMRT 1: 3C286       RA DE(2000.) 13h31m08.28s   30d30'32.9"
 Epoch
     51544.000000000    56371.000000000    2000.0027379070    2013.2162946536
 Precess out
     3.5392571970105   0.53248492555936    2000.0000000000    **3.5420542254091**
    **0.53123517233948**    3.5419185663391   0.53130182972364    2013.2162946536
GMRT 1: 3C286          precessed 13h31m46.74s   30d26'15.1"
GMRT 1: 3C286        rises and s- 20h52m00.33s -  7h34m47.11s
 ONLINE NOT STARTED,ISHMSTAT=  0 ABORTING
GMRT 1: UNAVAILABLE!

Put red underlined RA & DEC values in source.hdr as follows

<SRC NAME-3C147>  **3.5420542254091**  **0.53123517233948** <I-LO = default 1400000000> <BW=400000000> <(Decides LO > RF)1401000000> <Redundent number 70000000>

2.
In sampler.hdr enter antenna with connections as follows :

0x=> <C01>, 0y=> <C06>
1x=> <C09>, 1y=> <C12>
2x=> <S01>, 2y=> <S04>
3x=> <E06>, 3y=> <W06> For 4-Antennas (8-inputs)

4x=> <E02>, 4y=> <E04>
5x=> <S02>, 4y=> <S03>
6x=> <W02>, 4y=> <W04>
7x=> <W03>, 4y=> <E05> For 8-Antennas (16-inputs)

Run the following command :
For 4 antenna :
>./delay_update_pktizd.py -f -t -d -r -p <config_file> --dly_offset=0 0 0 0 0 0 0 0

For 8 antenna :
>./delay_update_pktizd.py -f -t -d -r -p <config_file> --dly_offset=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

## VI. Offline data analysis :

For 4 antenna , ".raw" data file can be analysed using native tax file program in the directory ~/Packetized_Corr/XAUI_Corr/4Ant_Corr/Ant_Tests/tax_prog_4Ant_V03 is used.

> cd ~/Packetized_Corr/XAUI_Corr/4Ant_Corr/tax_prog_4Ant_V03/

For plotting spectrum :
>./xtrgsb32_4ant_tstamp -v <.raw file> -c 1,511 -t 1,20 -r C00

For plotting single channel normalized value w.r.t. Time :
>./xtrgsb32_4ant_tstamp -v <.raw file> -c 128 -t 1,1000000 -r C00 -n 1

eg.

root@rchpc3:~/Packetized_Corr/XAUI_Corr/4Ant_Corr/tax_prog_4Ant_V03#

./xtrgsb32_4ant_tstamp -v ../Basic_Test/SFP_TEST/1373000328.66.corr.h5.raw -c 1,511 -t 1,1000
./xtrgsb32_4ant_tstamp -v ../Basic_Test/SFP_TEST/1373000328.66.corr.h5.raw -c 128 -t 1,5000
./xtrgsb32_4ant_tstamp -v ../Basic_Test/SFP_TEST/1373000328.66.corr.h5.raw -c 128 -t 1,5000 -r C00 -n 1

For 8 antenna , ".raw" data file can be analysed using native tax file program in the directory ~/Packetized_Corr/XAUI_Corr/8Ant_Corr/Ant_Tests/tax_prog_8Ant_V03 is used.

For plotting spectrum :
>./xtrgsb32_8ant_tstamp -v <.raw file> -c 1,511 -t 1,20 -r C00

For plotting single channel normalized value w.r.t. Time :
>./xtrgsb32_8ant_tstamp -v <.raw file> -c 128 -t 1,1000000 -r C00 -n 1

## VI. Raw to FITS file conversion for 8 Antenna dual pol (16-inputs):

NOTE: Code is kept in astro4:/temp30/ksanjay/SCLTA_PKT/
scp this directory to 32 bit m/c, e.g. astro0 is 32 bit m/c.
$ROOT_dir is any directory where you want to keep code.

>scp /temp30/ksanjay/SCLTA_PKT/ astro0:$ROOT_DIR/SCLTA_PKT/
# take care, $ROOT_DIR/data is data dir, so do not scp it, it's huge file.
# It is kept as sample file, instead scp your own pkt_corr data.

Compile code by following command.
> cd $ROOT_DIR/sclta_pkt_master/
> make clean;make
> cd $ROOT_DIR/gvfits_pkt.working/
> make clean;make

working directory for analysis:

> cd $ROOT_DIR/sclta_pkt_master/

1. Edit sampler.hdr for the connection made to pkt corr.
# 16 antennas to be entered, no antenna name to be duplicate.
# although it is 8 antenna, dual pole, it is used in 16 antenna

# single pol mode. Working antennna connections has to be accurate.
# others, leftover antenna names can be  arbitrary.

2. edit corrsel.hdr for
   a.  CHAN_NUM= 0:511:1
 b. LTA  = 1

# leave others untouched.

3. edit scan.hdr for
   OBJECT  = 3C48
   RA-APP  = 24.609356
   DEC-APP = 33.225975
   RA-MEAN = 24.609356
   DEC-MEAN= 33.225975
   OBSERVER= PKT CORR
   PROJECT = PKT_CORR
   Code  = PKT_CORR
   ANTMASK = 3fffffff
   BANDMASK= 3
   SEQ  = 0
   MJD_SRC = 56320.000000
   DRA  = 0
   DDEC  = 0
   RF  = 1299000000  1299000000
   FIRST_LO= 1350000000  1350000000
   BB_LO  = 51000000  51000000

# RA-APP, Dec-APP, RA-MEAN, DEC-MEAN, MJD_SRC, RF, FIRST_LO, BB_LO,  can be found out from parallel recording on GSB. by 'more lta' file.

4. edit gsb.hdr for
   GSB_ACQ_BW  = 400.0  /* 16.666 or 33.333  */
   GSB_CHAN_MAX = 512  /* 256/512
*/
# other parameters to be left as default in gsb.hdr.

4. execute raw-lta conversion by following command. In a given directory.
>./sclta -i $DATA_DIR/3c48.raw -l $DATA_DIR/3c48.lta -a antsys.hdr -s sampler.hdr -c corrsel.hdr -S scan.hdr -g gsb.hdr -b 0
$DATA_DIR is a place where raw/lta data is kept.

# -b 0 option leave as it is. ( data recorded on 32 bit m/c and analysis to be on 32 bit m/c).

5. $ROOT_DIR/gvfits_pkt.working/listscan 3c48.lta
# as per standard procedure.

6. $ROOT_DIR/gvfits_pkt.working/gvfits 3c48.log
# as per standard procedure.