Setup and Operations of the DBBC3

IVS TOW 2023, Haystack

Sven Dornbusch, MPIfR

Max-Planck-Institut
für Radioastronomie

MAX-PLANCK-GESELLSCHAFT

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  - Hardware Connections
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- Calibration

Observation Modes

Observation Modes

- DSC
- OCT
- DDC

Observation Modes

- **DSC**
- OCT
- DDC

- Direct Sampling Conversion
- 4GHz Bandwidth/IF
- Produces four 4Gbit/s streams per IF
- Recombination of recorded streams required

Observation Modes

- DSC
- **OCT**
- DDC

- (OCT)opus Mode
- 2 parallel FIR-Filters/IF
- Bandwidth of 256/512/1024/2048 MHz for each Filter
- Produces two output streams with up to 8Gbit/s each

Observation Modes

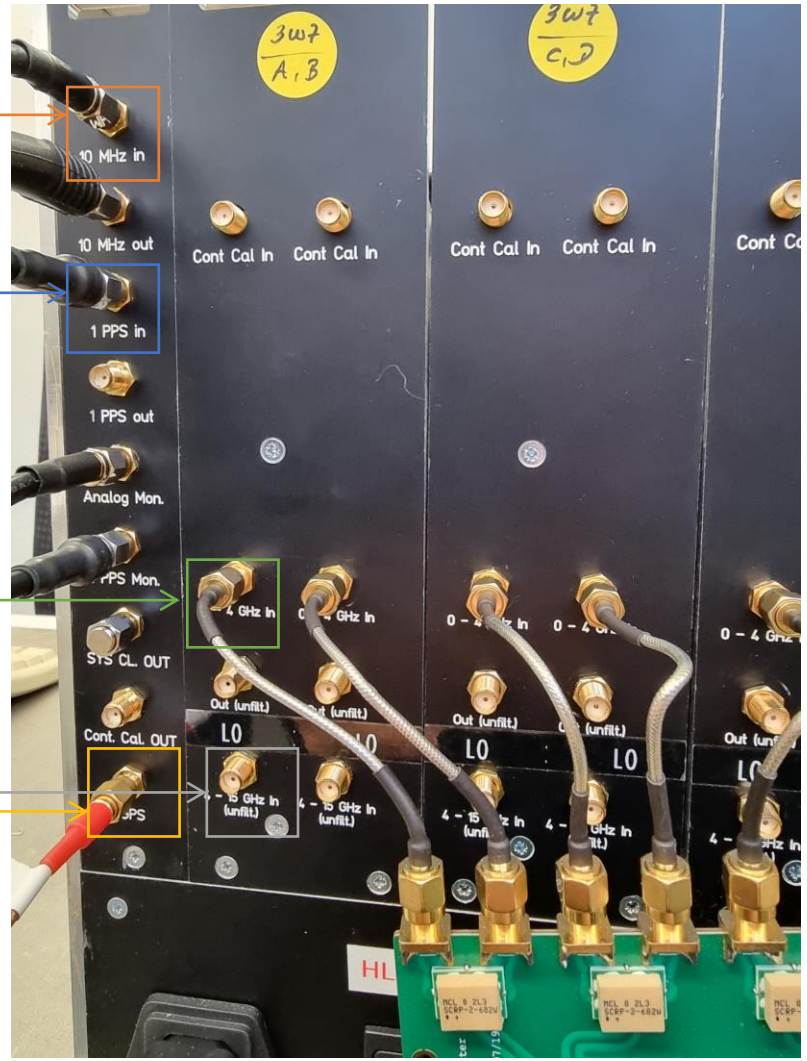
- DSC
- OCT
- **DDC**

- DDC_V: (VGOS)
  - 8 tunable BBCs/IF with upper/lower sideband each
  - Fixed 32 MHz BW/sideband
  - Specialized filters for 32MHz
- DDC_U (Universal)
  - 16 tunable BBCs/IF with upper/lower sideband each
  - 2, 4, 8, 16, 32, 62, 128 MHz BW/sideband
- DDC_E (EVN)
  - 8 tunable BBCs/IF with upper/lower sideband each
  - 2, 4, 8, 16, 32, 62, 128 MHz BW/sideband
  - Improved filters

Preparations

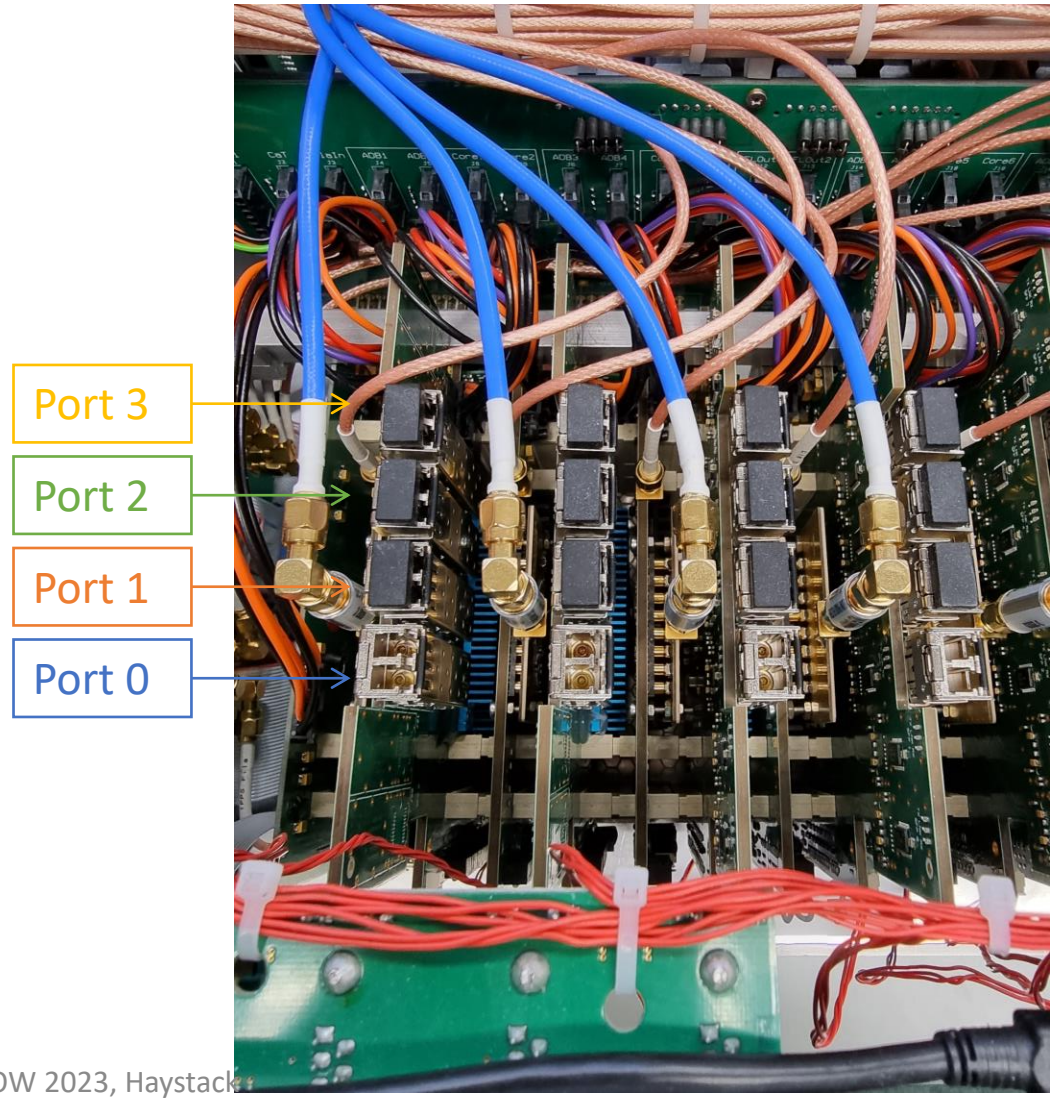
Hardware Connections

- Necessary Connections on the Back:
  - 10 MHz
  - 1 PPS
  - GPS
  - Signal Input 0-4 GHz
  - Or Signal Input 4-15 GHz
    - with downconversion
    - Connect “Out (unfilt.)” to “0-4 GHz in”



Hardware Connections

- Ethernet Output:
  - 4 Ethernet Ports/IF
  - DDC_V/E: Port 0
  - DDC_U: Port 0 and 1
    - BBCs 1-8: Port 0
    - BBCs 9-16: Port 1
  - OCT: Port 0 and 2
    - Filter 1 Port 0
    - Filter 2 Port 2
  - DSC: Port 0-3



Software Components

- Control Software
- Client
- Firmware
- Configuration Files
- Python Toolkit
- Field System

Software Components

- **Control Software**
- Client
- Firmware
- Configuration Files
- Python Toolkit
- Field System

- Located in C:\DBBC\bin folder
- One exe-File for each Observation Mode:
  - DBBC3 Control DSC_v120.exe
  - DBBC3 Control OCT_D_v120.exe
  - DBBC3 Control DDC_U_v130.exe
  - …
- Link to each File on Desktop

Software Components

- Control Software
- **Client**
- Firmware
- Configuration Files
- Python Toolkit
- Field System

- Located in C:\DBBC\bin folder
- DBBC client v4.exe
- Local Client used to communicate with Control Software
- Link on Desktop

Software Components

- Control Software
- Client
- **Firmware**
- Configuration Files
- Python Toolkit
- Field System

- Located in C:\DBBC_CONF\FilesDBBC folder
- One bit-File for each Observation Mode:
  - dbbc3_dsc_2hv2_221122.bit
  - dbbc3_oct_D_2hv2_221122.bit
  - dbbc3_ddc_U_v130-2hv2_180423.bit
  - …

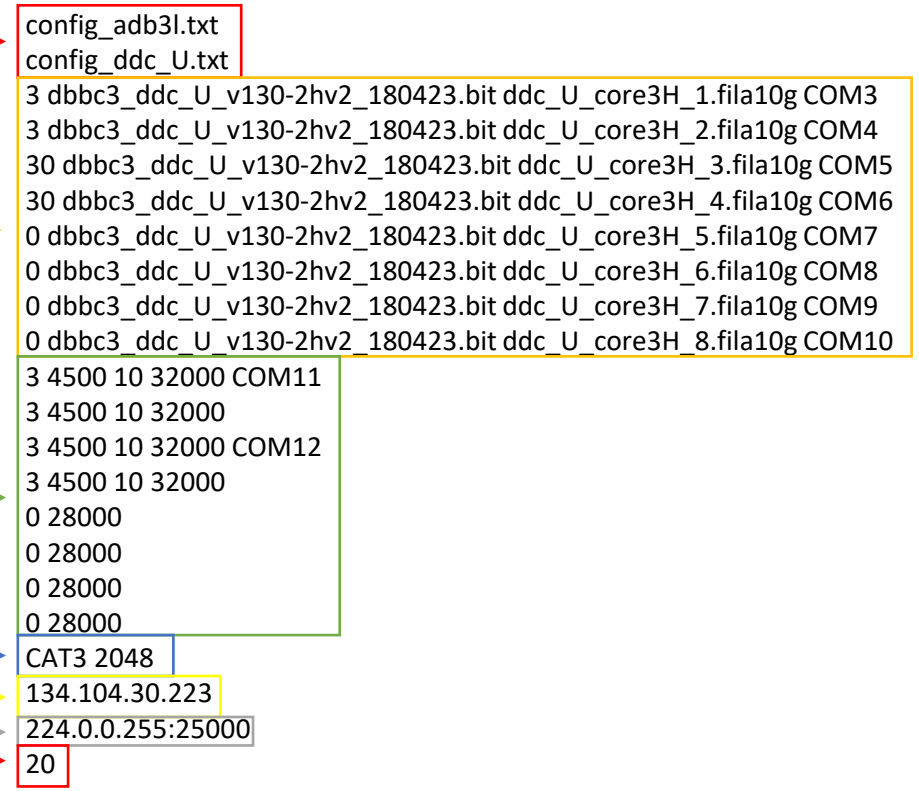
Software Components

- Control Software
- Client
- Firmware
- **Configuration Files**
- Python Toolkit
- Field System

- Located in C:\DBBC_CONF folder
  - C:\DBBC_CONF\DSC_120 for DSC Mode
  - C:\DBBC_CONF\OCT_D_120 for OCT_D Mode
  - C:\DBBC_CONF\DDC_U_130 for DDC_U Mode
  - C:\DBBC_CONF for DDC versions before v130
  - C:\DBBC_CONF for config_adb3l.txt
- Five types of configuration files
  - Main config file
  - Sampler config file
  - Core3H config files (one for each IF)
  - BBC config file (for DDC modes)
  - Filter tap files (for OCT_D mode)

Main Config File

- Example: dbbc3_config_file_ddc_U_130.txt
- References to other config files
- Init Part for Core3H-Boards
- Init Part for GCoMo-Modules
- Synthesizer Config
- IP-Address of DBBC3
- IP and Port for Multicast Group
- Maximum Number of Phasechecks



Main Config File

- Init Part for Core3H-Boards
  - Core3H Status:
    - 3: Installed Core3H and Signal connected to IF
    - 30: Installed Core3H and NO Signal connected
    - 0: No Installed Core3H
  - Core3H Firmware
  - Core3H Config File
  - Serial COM Port

```
config_adb3l.txt
config_ddc_U.txt
3 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_1.fila10g COM3
3 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_2.fila10g COM4
30 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_3.fila10g COM5
30 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_4.fila10g COM6
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_5.fila10g COM7
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_6.fila10g COM8
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_7.fila10g COM9
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_8.fila10g COM10
3 4500 10 32000 COM11
3 4500 10 32000
3 4500 10 32000 COM12
3 4500 10 32000
0 28000
0 28000
0 28000
0 28000
CAT3 2048
134.104.30.223
224.0.0.255:25000
20
```

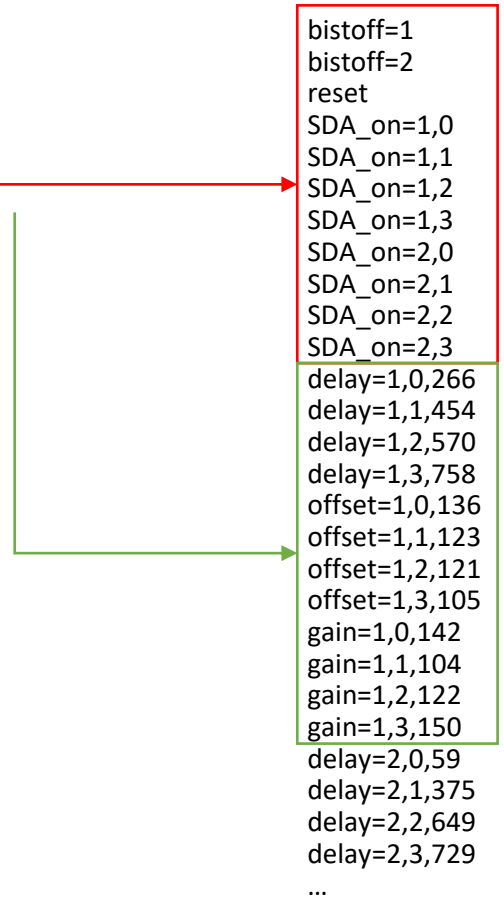
Main Config File

- Init Part for GCoMo-Modules
  - GCoMo Status:
    - 3: Installed
    - 0: Not Installed
  - Synthesizer Frequency for Down Conversion
    - In MHz
    - ½ of LO-Frequency
  - Attenuation for Synthesizer Frequency
    - in dBm
  - AGC Power Target
  - COM Port for Synthesizer Communication
    - 2 IFs share one Synthesizer (with 2 Outputs each)

config_adb3l.txt
config_ddc_U.txt
3 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_1.fila10g COM3
3 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_2.fila10g COM4
30 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_3.fila10g COM5
30 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_4.fila10g COM6
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_5.fila10g COM7
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_6.fila10g COM8
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_7.fila10g COM9
0 dbbc3_ddc_U_v130-2hv2_180423.bit ddc_E_core3H_8.fila10g COM10
3 4500 10 32000 COM11
3 4500 10 32000
3 4500 10 32000 COM12
3 4500 10 32000
0 28000
0 28000
0 28000
0 28000
CAT3 2048
134.104.30.223
224.0.0.255:25000
20

Sampler Config File

- Example: adb3l_config.txt
  - Static Part
    - Do not Change
  - Delay, offset and gain for each sampler
    - command=board,sampler,value
    - board[1-8]
    - sampler[0-3]
    - Value determined by Calibration Procedure



Core3H Config Files

- Example: ddc_U_core3H_1.fila10g
  - Old style (v126 and older):

```
core3_init
core3_mode pfb
regwrite core3 0 0x00000000
regwrite core3 1 0xBFBFBFBF
regwrite core3 9 1
reboot
inputselect vsi1-2-3-4
vsi_samplerate 128000000
splitmode on
reset
vdif_frame 2 16 8000 ct=off
tengbcfg eth0 ip=192.168.1.16 gateway=192.168.1.1 nm=27
tengbarp eth0 2 00:60:dd:42:38:e2
destination 0 192.168.1.2:46220
destination 1 none
timesync
start vdif
sysstat
```

  - New style (v130):

```
reboot
core3_init
bbc_bandwidth 128
vdif_frame 2 16 8000 [optional]
tengbcfg eth0 ip=192.168.1.16 gateway=192.168.1.1 nm=27
tengbarp eth0 2 00:60:dd:42:38:e2
destination 0 192.168.1.2:46220
destination 1 none
timesync
start vdif
sysstat
```

Core3H Config Files

- Configuring BBC bandwidth
  - (v126 and older): vsi_samplerate with decimation had to be used to set correct output bandwidth
  - (v130): new bbc_bandwidth command
    - DDC_U/E: Change according to used BBC-bandwidth:
      - 128 MHz: bbc_bandwidth 128
      - 64 MHz: bbc_bandwidth 64
      - 32 MHz: bbc_bandwidth 32
      - …
    - DDC_V: not used, fixed at 32 MHz
    - DSC/OCT_D: command not used

```
reboot
core3_init
bbc_bandwidth 128
vdif_frame 2 16 8000 [optional]
tengbcfg eth0 ip=192.168.1.16 gateway=192.168.1.1 nm=27
tengbarp eth0 2 00:60:dd:42:38:e2
destination 0 192.168.1.2:46220
destination 1 none
timesync
start vdif
sysstat
```

Core3H Config Files

- Configuring VDIF-Frame format:
  - Optional if default settings are used:
    2 bit, 16 channels with 8000 bytes framesize
  - vdif_frame:
    - Bits/sample: default 2
    - #Channels/vdif_frame: default 2x(#BBCs/Output Port)
      change if using vsi_bitmask to mask out channels!
      Not #Channels in total, be careful with DDC_U!
    - Data-Bytes/Frame: default 8000
    - (The “ct=off” parameter has been removed in version v130.)

```
reboot
core3_init
bbc_bandwidth 128
vdif_frame 2 16 8000 [optional]
tengbcfg eth0 ip=192.168.1.16 gateway=192.168.1.1 nm=27
tengbarp eth0 2 00:60:dd:42:38:e2
destination 0 192.168.1.2:46220
destination 1 none
timesync
start vdif
sysstat
```

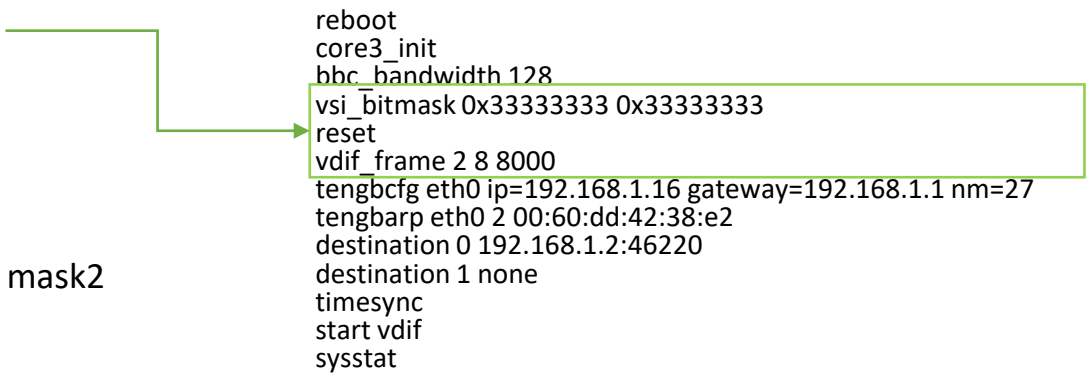
Core3H Config Files

- 10G Ethernet setup:
  - Configuration of Ethernet Ports
    - tengbcfg: set source configuration for ethernet port
    - tengbarp: set the destination MAC-addresses for ethernet port and subnet
    - destination: set destination IP and Port for given output stream, set to none if output is not used

```
reboot
core3_init
bbc_bandwidth 128
vdif_frame 2 16 8000 [optional]
tengbcfg eth0 ip=192.168.1.16 gateway=192.168.1.1 nm=27
tengbarp eth0 2 00:60:dd:42:38:e2
destination 0 192.168.1.2:46220
destination 1 none
timesync
start vdif
sysstat
```

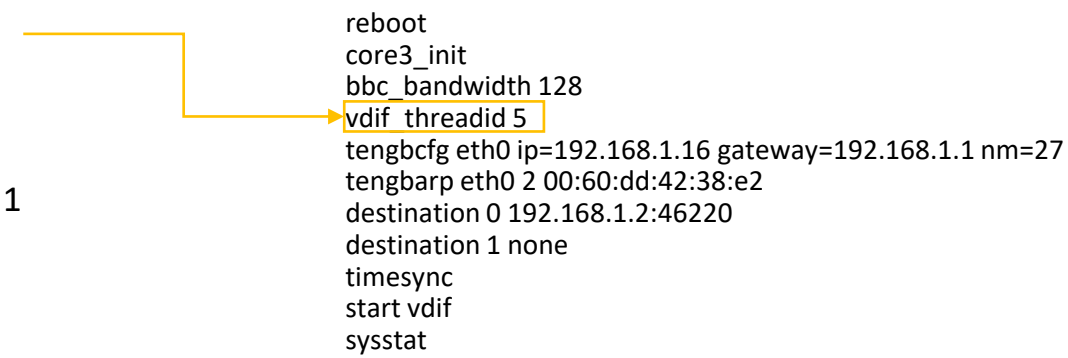
Core3H Config Files – Bitmask

- Use vsi_bitmask to mask out channels
- DDC_U v130:
  - vsi_bitmask mask2 mask1
    mask1 = Bitmask for BBCs 1-8
    mask2 = Bitmask for BBCs 9-16
  - If mask2 is skipped, mask1 will be copied to mask2
- DDC_E/V v130:
  - vsi_bitmask mask1
  - mask1 = Bitmask for BBCs 1-8
- All masks need to have the same number of bits
- If you mask out channels, always adjust the number of channels in the vdif_frame accordingly!
- Reset required after setting bitmask
- More Info about setting the bitmask:
  https://deki.mpifr-bonn.mpg.de/Cooperations/DBBC3/DBBC3_FAQ?highlight=FAQ



Core3H Config Files – Change Thread ID

- To Change the Base Thread ID (v130):
  - New command vdif_threadid
  - Sets the base thread id for port 0
  - Port 1 (DDC_U) will have base thread id + 1



BBC Config File

- Initial Configuration for the BBCs:
  - BBC Number (1-128)
  - Frequency
  - Bandwidth
- BBC Numbering for DDC_U:

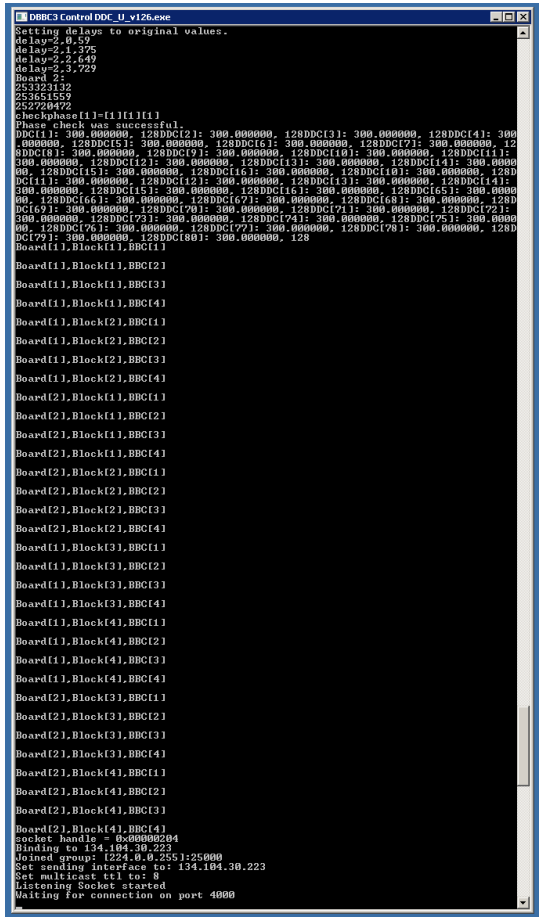
Board 1	Board 2	Board 3	Board 4	Board 5	Board 6	Board 7	Board 8
1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64
65-72	73-80	81-88	89-96	97-104	105-112	113-120	121-128

1 300.0 128
2 300.0 128
3 300.0 128
4 300.0 128
5 300.0 128
6 300.0 128
7 300.0 128
8 300.0 128
9 300.0 128
10 300.0 128
11 300.0 128
12 300.0 128
13 300.0 128
14 300.0 128
15 300.0 128
16 300.0 128
10 300.0 128
11 300.0 128
12 300.0 128
13 300.0 128
14 300.0 128
15 300.0 128
16 300.0 128
…

Startup Routine

Startup Routine

1. Start Control Software on Desktop
2. Load Firmware(Y/N)
   (Can be skipped if correct firmware already loaded)
3. Load Configuration(Y/N)
4. Connect with Client/Python Tool/FS
5. Perform Post-Startup System Checks
6. Ready for Observation



Post-Startup System Check

Post-Startup System Check

1. Check GCoMo Power Levels
2. Phasecheck
3. Check PPS Synchronization
4. Check Time Synchronization
5. Check Sampler Statistics
6. Check BBC Statistics

Post-Startup System Check

1. **Check GCoMo Power Levels**
2. Phasecheck
3. Check PPS Synchronization
4. Check Time Synchronization
5. Check Sampler Statistics
6. Check BBC Statistics

- Use **dbbcifa**, **dbbcifb**, … commands to check if each used GCoMo has the correct power levels:
- dbbcifa/2,**20**,agc,**31433**,32000
  - GCoMo Input (1-Direct Input, 2-Down Conversion)
  - Attenuation level (ideally between 10-40)
  - Automatic Gain Control (agc – AGC on, man – AGC off)
  - Power Level (should close to power target)
  - Power Target (32000 ideal for 4 GHz Input)

Post-Startup System Check

1. Check GCoMo Power Levels
2. **Phasecheck**
3. Check PPS Synchronization
4. Check Time Synchronization
5. Check Sampler Statistics
6. Check BBC Statistics

- **Command: checkphase**
  - This command will check if phases for the used samplers are correctly aligned
  - If the check fails, make sure that the **GCoMo Power Levels** for the failed Board are correct, and repeat the check.
  - If the check still fails, **restart the Control Software**. Loading the Firmware can be skipped.
  - If the check still fails, there may be a **hardware issue**. Contact Support. Include the latest logfile (in Folder C:\)

Post-Startup System Check

1. Check GCoMo Power Levels
2. Phasecheck
3. **Check PPS Synchronization**
4. Check Time Synchronization
5. Check Sampler Statistics
6. Check BBC Statistics

- **Command: pps_delay**
  - Checks the delay between internal (generated) and external PPS
  - Should be **below 100ns** for each used IF.
  - **Restart Control Software** if Value too high.
    Loading Firmware can be skipped.
  - **Careful**: If the external PPS comes from the GPS, there may be a drift over time between internal and external PPS.

Post-Startup System Check

1. Check GCoMo Power Levels
2. Phasecheck
3. Check PPS Synchronization
4. **Check Time Synchronization**
5. Check Sampler Statistics
6. Check BBC Statistics

- **Command: time**
  - Check that the **vdif-timestamps** are correct.
    All timestamps should be identical.
  - If not, **check GPS connection** and **restart Control Software**.
    Loading Firmware can be skipped.

Post-Startup System Check

1. Check GCoMo Power Levels
2. Phasecheck
3. Check PPS Synchronization
4. Check Time Synchronization
5. **Check Sampler Statistics**
6. Check BBC Statistics

- **Command: samplerstats=board_nr**
  - "**ADB3L[] Power**" The four values should be less than 1-2% off from each other (marked as [OK]).
    If not, a recalibration of the **gain** might be required.
  - Example:
    ADB3L[1] Power:
    Sampler 0: 72206203[OK]
    Sampler 1: 72448527[OK]
    Sampler 2: 72001701[OK]
    Sampler 3: 71414116[OK]
  - "**ADB3L[] Bstat**." Should be at 50% +- 1% (marked as [OK])
    If not, a recalibration of the **offset** might be required.
  - Example:
    ADB3L[1] Offset:
    Sampler 0: 63807624 49.85%[OK]
    Sampler 1: 64006127 50.00%[OK]
    Sampler 2: 64098706 50.08%[OK]
    Sampler 3: 64161981 50.13%[OK]
  - "**ADB3L[] Delay**" has already been checked during Phasecheck
  - This values could be flagged with [Not OK] if you are using less than 4 GHz Input bandwidth although the phasecheck was successful.
    In this case this is a false error flag an can be ignored. Otherwise redo the phasecheck which will work regardless of input bandwidth.

Post-Startup System Check

1. Check GCoMo Power Levels
2. Phasecheck
3. Check PPS Synchronization
4. Check Time Synchronization
5. Check Sampler Statistics
6. **Check BBC Statistics**

- **Command: dbbcXX**
  - Replace XX with the BBCs number (01-128)
  - Example response:
    dbbc001/ 300.000000,a,128,1,agc,26,26,15244,15004,0,0;
  - Check that **frequency** and **bandwidth** are correct
  - Power levels should be around 15k,
    gain within range (0-255), but this is a recommendation,
    not a strict requirement

Calibration

Calibration

- When do you need to recalibrate?
  - **Gain**: Core3H-Power is systematically off during Post-Startup System Check
  - **Offset**: Core3H-Bstat is systematically off during Post-Startup System Check
  - **Delay**: Always recalibrate if you needed to recalibrate gain or offset.
  - Check for **RFI** in the band first, this can in some cases lead to deviation in gain and offset.
- **Only perform calibration if you have a clean 4GHz Signal source**:
  - 4 GHz bandwidth clean noise (from noise generator or receiver)
  - Power must be stable during the calibration process!!!
  - Enough Power (32k GCoMo Power Level)
  - No RFI in the band!!!

Offset-Calibration

1. **Increase the attenuation** of the corresponding GCoMo so that the **power level is between 5 and 10k**:
   - dbbcifa=2,40
   - dbbcifa/ 2,40,man,1,**5557**,32000;
2. Issue the Command: **cal_offset=board_nr[1-8]**
   - Example: cal_offset=1
   - The result is shown in the Command windows of the Control Software, not the Client:
     Sampler[0], best offset 136
     offset=1,0,136
     Sampler[1], best offset 124
     offset=1,1,124
     Sampler[2], best offset 120
     offset=1,2,120
     Sampler[3], best offset 102
     offset=1,3,102
3. Change the values in the **config_adb3l.txt** according to the result of the calibration
   - offset=1,0,136
     offset=1,1,124
     offset=1,2,120
     offset=1,3,102
4. **Reset the attenuation** in the GCoMo to agc to reach power level of 32k, restarting the control software is not necessary
   - dbbcifa=2,agc

Gain-Calibration

1. Make sure the power level of the GCoMo is **around 32k**, **manual mode** is recommended:
   - dbbcifa=2,man
   - dbbcifa/ 2,4,man,1,**32443**,32000;
2. Issue the Command: **cal_gain=board_nr[1-8]**
   - Example: cal_gain=1
   - The result is shown in the Command windows of the Control Software, not the Client:
     Sampler[0], best gain 129
     Sampler[1], best gain 97
     Sampler[2], best gain 128
     Sampler[3], best gain 159
3. Change the values in the **config_adb3l.txt** according to the result of the calibration
   - gain=1,0,129
     gain=1,1,97
     gain=1,2,128
     gain=1,3,159
4. **Reset the attenuation** in the GCoMo to agc, restarting the control software is not necessary.
   - dbbcifa=2,agc

Delay-Calibration

1. Make sure the power level of the GCoMo is **around 32k**, **manual mode** is recommended:
   - dbbcifa=2,man
   - dbbcifa/ 2,4,man,1,**32443**,32000;
2. Issue the Command: **cal_delay=board_nr[1-8]**
   - Example: cal_delay=1
   - The result is shown in the Command windows of the Control Software, not the Client
     0->1, Best difference = 194 with corr_value = 254646768
     1->2, Best difference = 142 with corr_value = 254000252
     2->3, Best difference = 214 with corr_value = 253237046
     Sampler[0]->delay=247
     delay=1,0,247
     Sampler[1]->delay=441
     delay=1,1,441
     Sampler[2]->delay=583
     delay=1,2,583
     Sampler[3]->delay=797
     delay=1,3,797
3. Change the values in the **config_adb3l.txt** according to the result of the calibration
   - delay=1,0,247
     delay=1,1,441
     delay=1.2.583
     delay=1.3.797
4. **Reset the attenuation** in the GCoMo to agc, restarting the control software is not necessary.
   - dbbcifa=2,agc

Thank you, any questions?