APPLICATION NOTE

EAGLE_16-125-RBC

AN2101

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1 APPLICABLE DOCUMENTS

1.1 TECHWAY documents

Table 1: TECHWAY documents

Ref.	Title	Origin	Document ID
[T1]	EAGLE_16-125 user manual	TECHWAY	UM2100
[T2]	EAGLE_16-125's wide band user manual of WEB interface	TECHWAY	UM2113
[T3]	EAGLE_16-125's wide band user manual of SNMP agent	TECHWAY	UM2126
[T4]	EAGLE_16-125's user manual of TEA API	TECHWAY	UM2130
[T5]	Document list for EAGLE_16-125	TECHWAY	UM2199

2 WARNING

INFORMATION AND FIGURES SUBJECT TO CHANGE WITHOUT PRIOR NOTICE.

USER ASSUMES ENTIRE RISK FOR THE USE OF THE PRODUCT.

TECHWAY SHALL NOT BE HELD LIABLE FOR ANY SYSTEM DAMAGE, DATA LOSS OR OTHER DAMAGES RESULTING FROM THE USE OR MISUSE OF THE PRODUCT.

3 SCOPE OF DOCUMENT

EAGLE_16-125 allows users to tune decimation and frequency response of the DDC to fit a wide range of applications.

When configured with wide band baseline **BL_EAGLE_REBECCA_FWx_SWy**, EAGLE_16-125's DDC looks like in *Figure 1*.

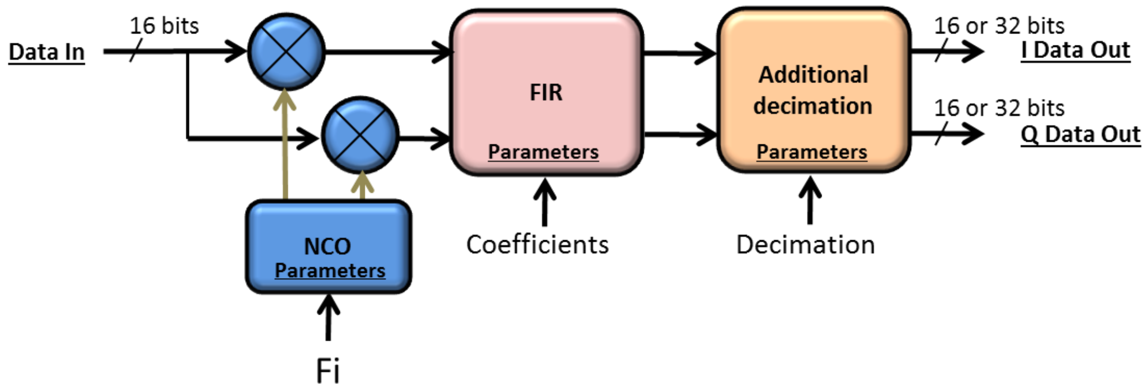

Figure 1: EAGLE_16-125 wide band DDC

Here are the parameters which are customizable:

- DDS's central frequency
- FIR filter's frequency response
- Additional decimation

This application note presents how to configure the DDC to fit a specific need.

4 DESIGNING EAGLE_16-125 WIDE BAND DDC'S PROCESSING

4.1 DDC filtering specifications

Through this application notes, a filter will be designed. This filter will have the following specifications:

- Sample frequency (f_s): 100 MHz
- Decimation: 16
- Pass-band ripple: 0.1 dB
- Cutoff frequency: 2 MHz
- Stop-band frequency: 3MHz
- Stop-band attenuation: 100 dB

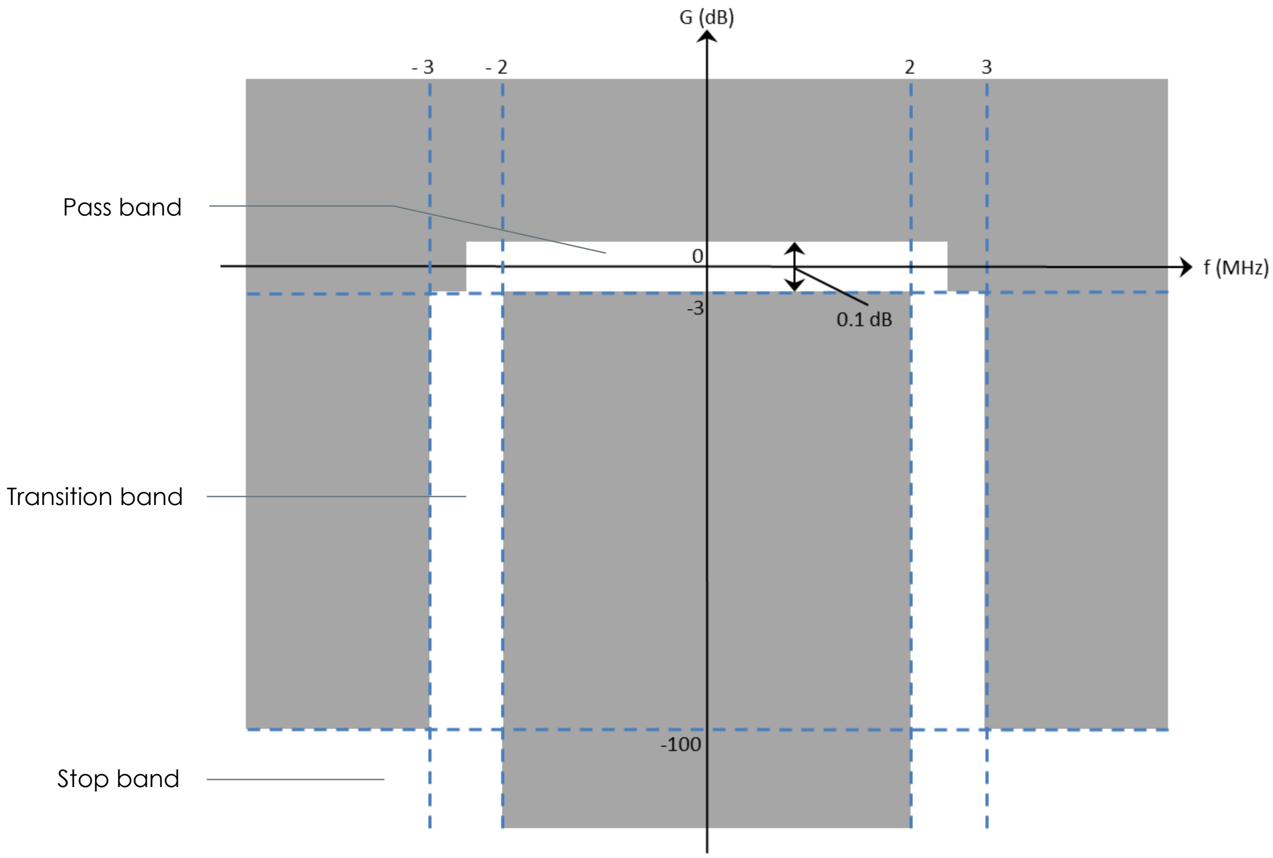

Figure 2: Filter specifications

4.1.1 FIR filter

4.1.1.1 Filter design

The FIR filter (for Finite Impulse Response filter) is a decimate-by-8 410-taps symmetric FIR filter.

Here are the chosen parameters for this example FIR:

- Decimation: 8 (fixed)
- Cutoff frequency: 2 MHz
- Pass-band ripple: 0.1 dB
- Stop band attenuation: 100 dB

With these parameters, the FIR has the following frequency response which meets the specification:

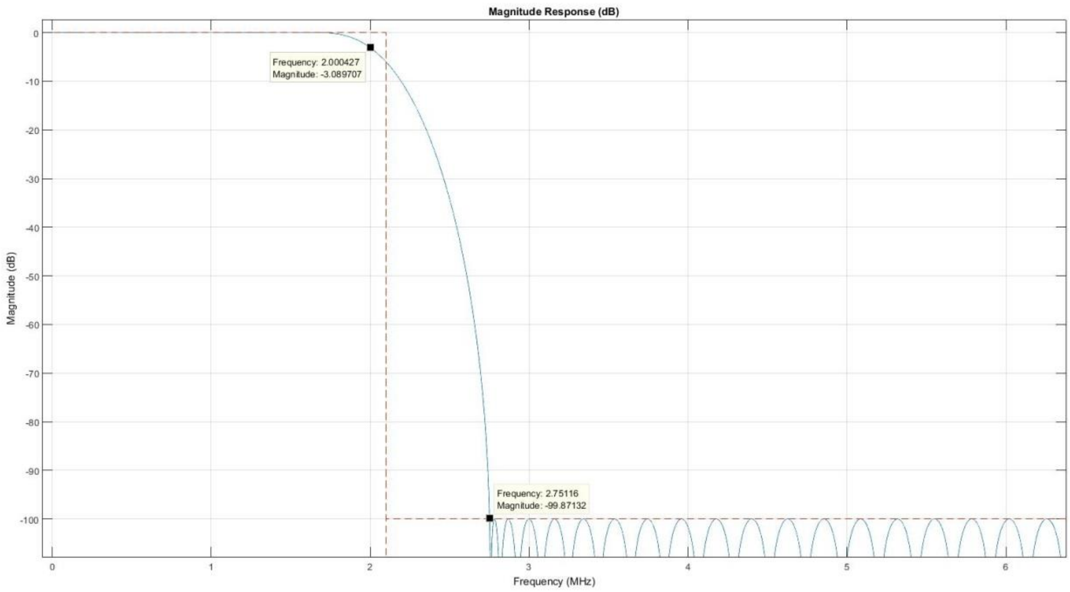

Figure 3: FIR gain Bode diagram

By looking at the pass-band ripple of the FIR, we can tell that the specifications are met as well (*Figure 4*).

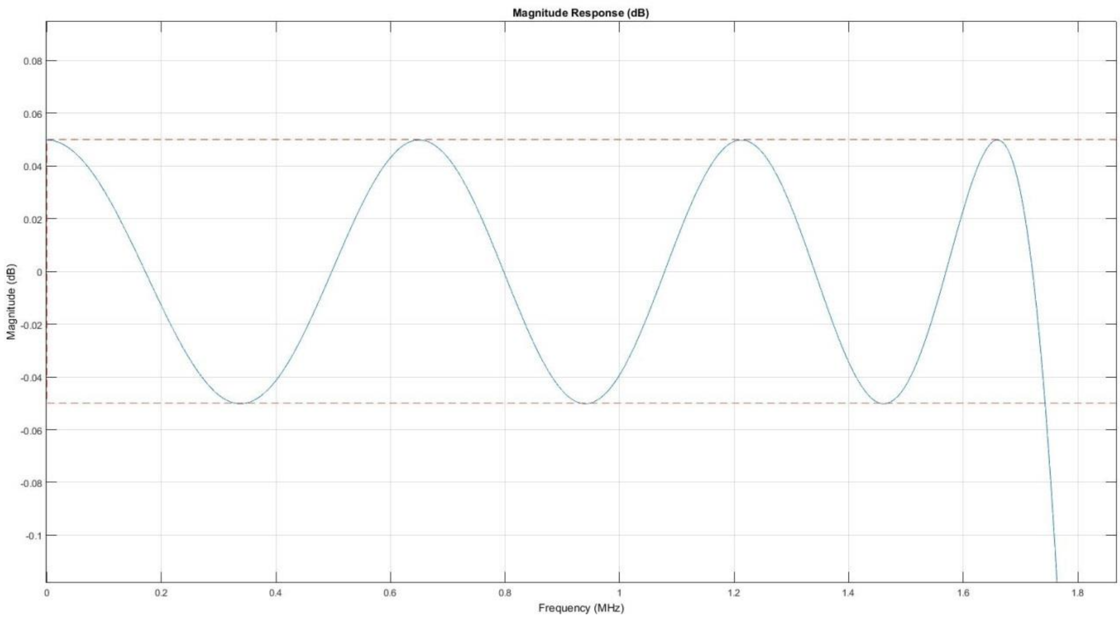

Figure 4: FIR pass-band ripple

4.1.1.2 FIR configuration

FIR filter's frequency response can be adjusted by loading a custom coefficient set. This set can be loaded either through the WEB interface (*Figure 5*) or by an SNMP command (*Figure 6*). Coefficient set have to be provided respecting Xilinx filter coefficient format with file extension ".coe" (see the Appendix section at the end of this document).

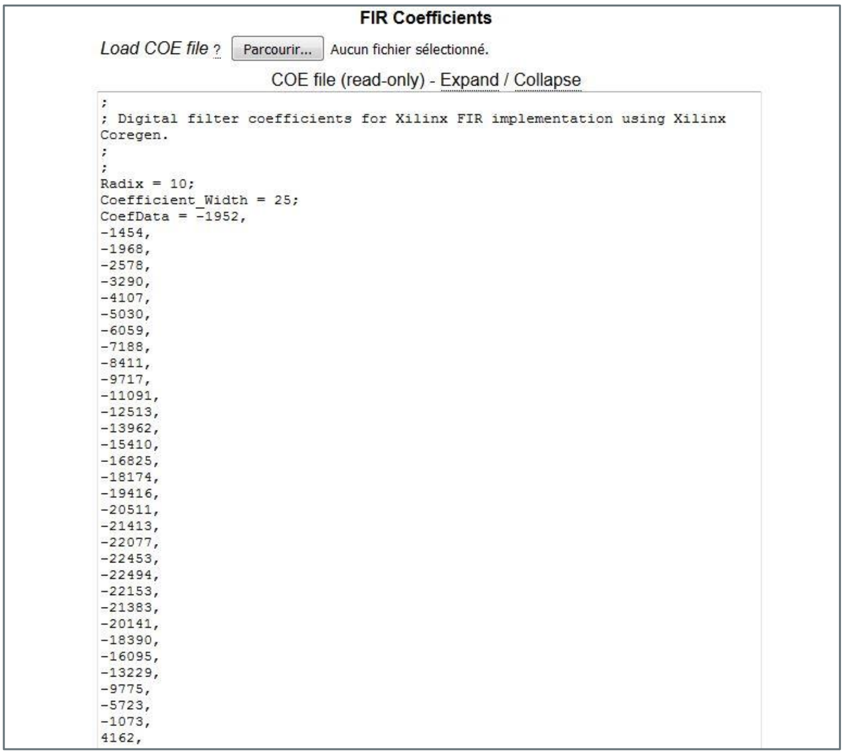

Figure 5: FIR filter's coefficient set loading through WEB interface

```
echo "FIR coefficient loading"
IP=192.168.0.253
pu_num=0
coefile=$(cat ../Rebecca_fs_100_MHz_fc_2000_kHz.coe)
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.8.0 s "$coefile"
```

Figure 6: SNMP commands example for FIR coefficient file loading

4.1.2 Second stage: Additional decimation

4.1.2.1 Decimation configuration

As the FIR filter has a fixed decimation factor of 8, an additional decimation is available in order to obtain the required 16 decimation factor. This additional decimation decimates FIR's output by a factor between 1 and 8, which narrows DDC output bandwidth and reduce its output rate.

Additional decimation configuration can be made either through the EAGLE_16-125 WEB interface (*Figure 7*) or via an SNMP command (*Figure 8*).

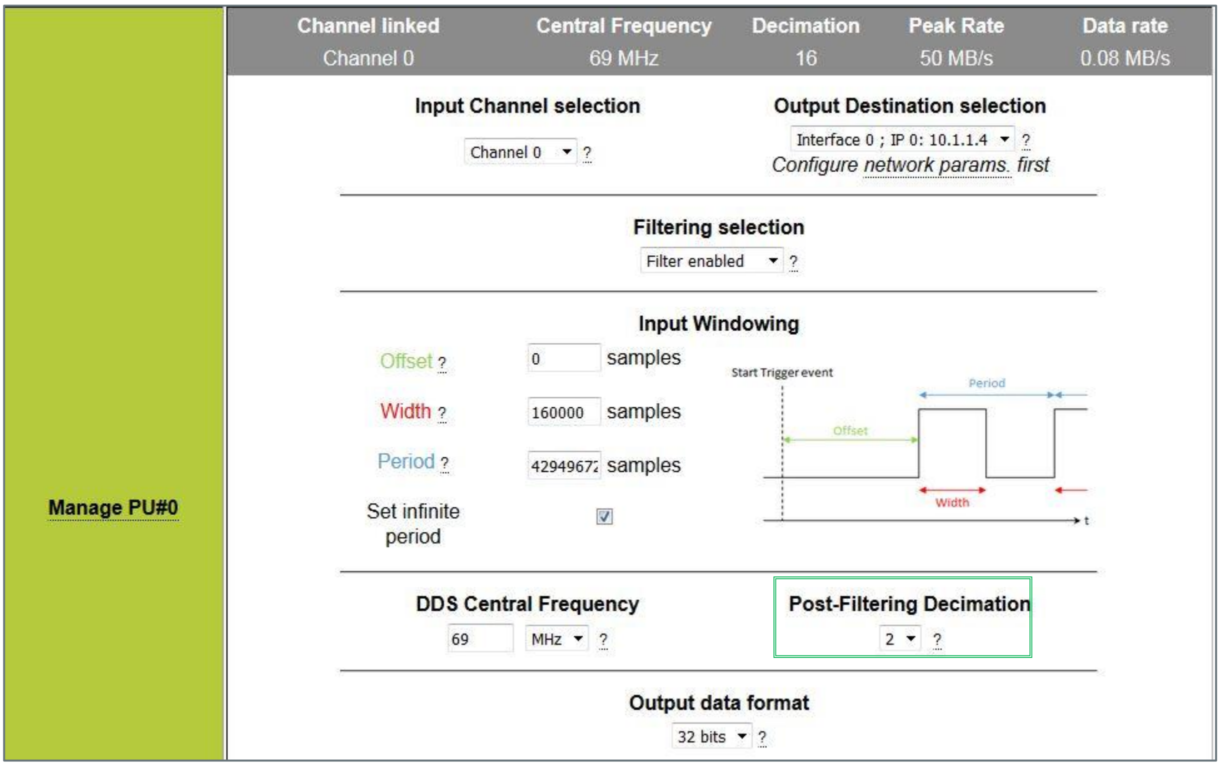

Figure 7: Post-filtering decimation setting through WEB interface

```
echo "DDC additional_decimation setting"
IP=192.168.0.253
pu_num=0
additional_decimation=2
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.7.0 i ${additional_decimation}
```

Figure 8: SNMP commands for additional decimation setting

Note:

It is important to configure the decimation factor prior to configure windowing **width**. Decimation factor value is used by EAGLE_16-125 to calculate the real windowing width, which includes DDC filter's rise time, which depends on the decimation factor.

5 DDC FILTERING FREQUENCY RESPONSE VERIFICATION

To verify the frequency response of the previously designed filter, the EAGLE_16-125 wide band will be fed with a 70 MHz signal on analog input n°0. This input will be mapped to processing units 0 to 4 so as to each processing unit can treat a specific frequency range, each by using a different demodulation frequency. The sampling frequency will be 100 MHz.

We are going to see how to configure the EAGLE_16-125 to do this verification.

5.1 EAGLE_16-125 configuration

5.1.1 Acquisition parameters

Acquisition parameters consist in several configurations:

- sampling clock frequency
- trigger edge and sampling clock (internal or external)
- trigger electrical standard

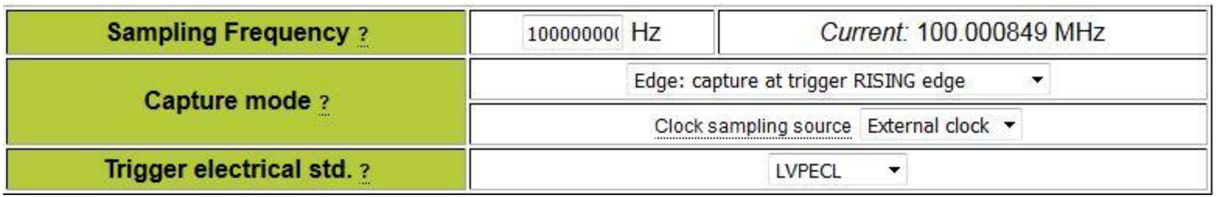

Figure 9: Acquisition parameters

<u>Note:</u>

It is important to configure the sampling clock frequency <u>**prior**</u> to configure the DDS frequencies (*Figure* 9). Sampling clock frequency is used by EAGLE_16-125 to calculate the configuration values which will be applied to the DDS.

Now that the acquisition parameters are set, filtering can be configured.

5.1.2 Filtering parameters

In order to verify the filter's frequency response in one recording session, five processing units are used simultaneously. On the first five processing units (PU [0...4]), central frequencies of the DDS are set to observe filter attenuation at different frequencies (***Erreur ! Source du renvoi introuvable.***).

Table 2: Central frequencies of the Processing Units' DDS

PU number	f_{DDS} (MHz)	Frequency of interest (MHz)
0	69	1
1	68	2
2	67.5	2.5
3	67	3
4	65	5

In order to have a decent FFT, widths of the windowing on the five processing units are set to get 10 000 I/Q complex output samples. We do not use any offset, and the period is set to infinity (*Figure 10*).

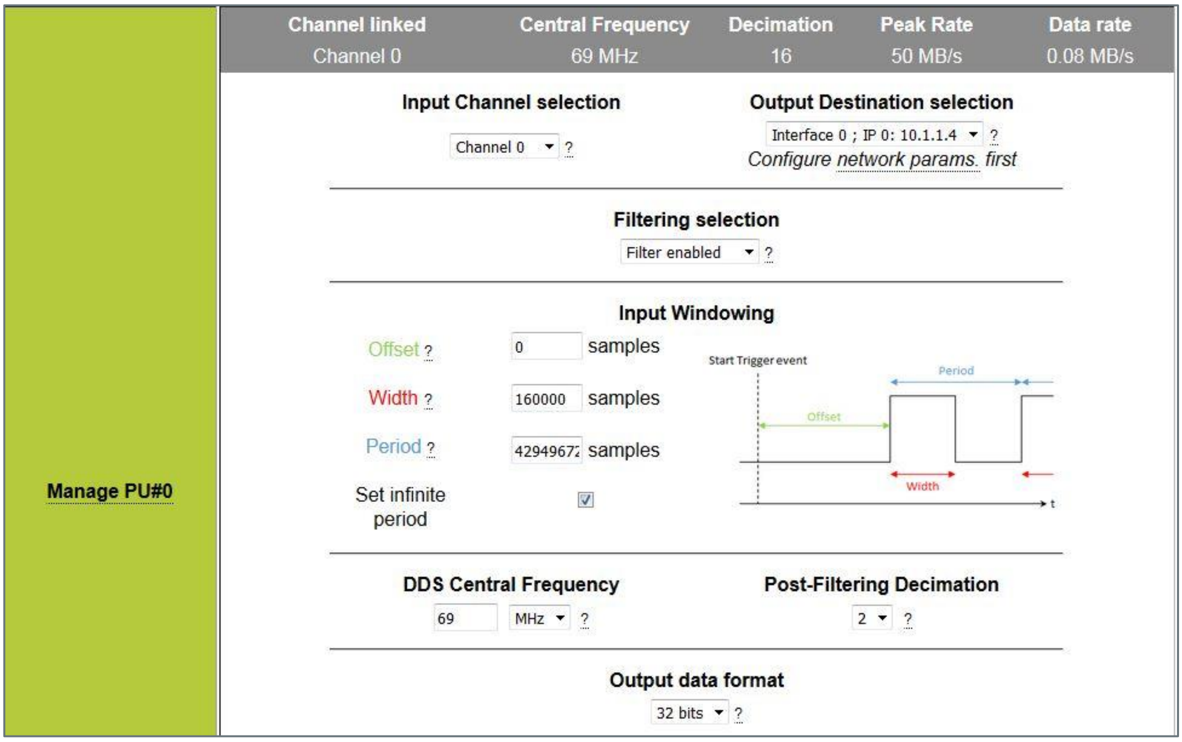

Figure 10: Processing Unit (PU) number 0 configuration

Once the five processing units configured, user can check the filtering configuration on the summary configuration page (*Figure 11*).

Processing Unit#	Channel linked	Central Frequency	Decimation	Peak Rate	Data rate
Manage PU#0	Channel 0	69 MHz	16	50 MB/s	0.08 MB/s
Manage PU#1	Channel 0	68 MHz	16	50 MB/s	0.08 MB/s
Manage PU#2	Channel 0	67.5 MHz	16	50 MB/s	0.08 MB/s
Manage PU#3	Channel 0	67 MHz	16	50 MB/s	0.08 MB/s
Manage PU#4	Channel 0	65.000001 MHz	16	50 MB/s	0.08 MB/s

(Summary configuration)

Figure 11: Configuration summary of the five processing units

5.1.3 Network configuration

Do not forget to configure the network in order to correctly receive EAGLE_16-125 data.

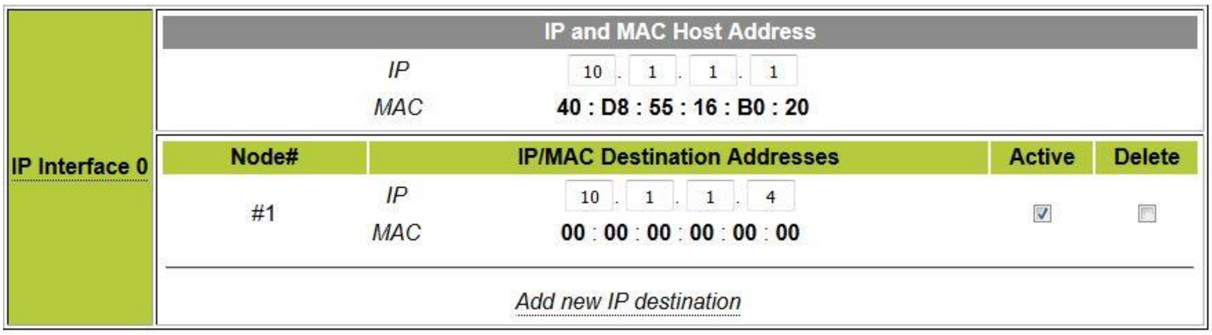

Figure 12: Network configuration

5.2 Results

With these configurations applied, the outputs of the five processing are recorded, the complex I/Q modulus spectrums calculated and plotted. Here are the results:

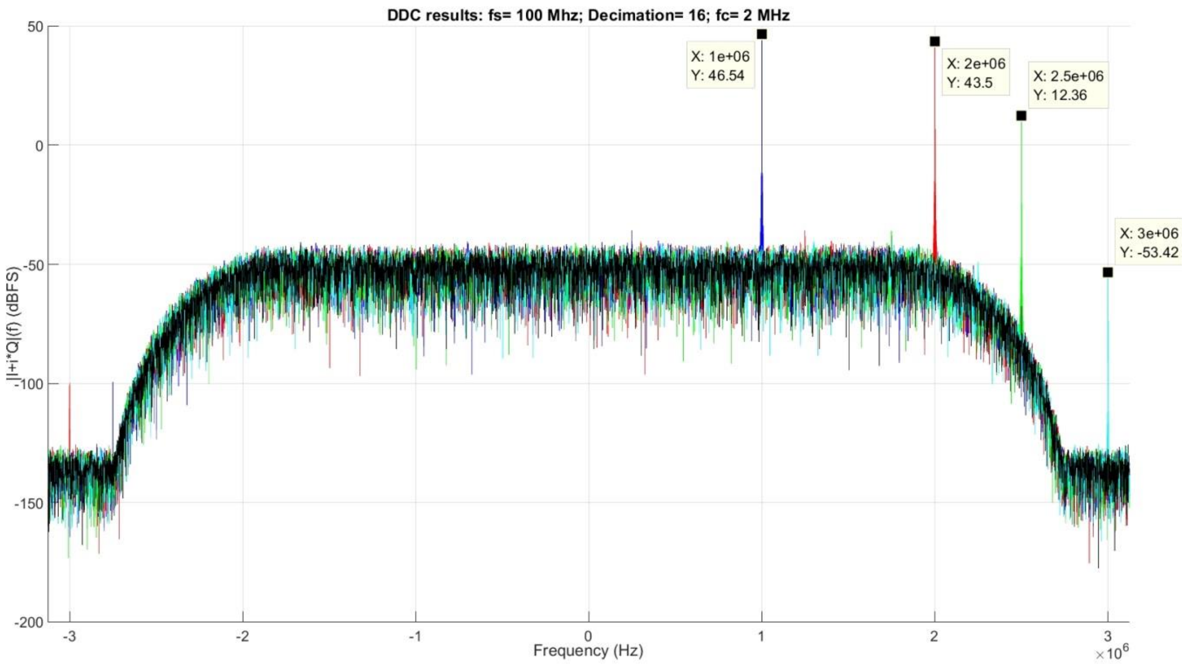

Figure 13: Complex signal modulus spectrums from processing units' outputs

Erreur ! Source du renvoi introuvable. explains the *Figure 13* results.

Table 3: Processing Units outputs' results

PU number	Plot color	Frequency (MHz)	Comments
0	Blue	1	Within filter's bandwidth
1	Red	2	Filter's cutoff frequency: -3dB from bandwidth gain
2	Green	2.5	Filter's roll-off
3	Cyan	3	Filter's stopband -100 dB from bandwidth gain
4	Black	5	Completely attenuated: filter's attenuation goes stronger as frequency increases

The designed filter fits the specification's needs.

6 APPENDIX

6.1 FIR filter coefficient set coe file

Here is the coe file used within this application note to configure the FIR filter:

```
;
; Digital filter coefficients for Xilinx FIR implementation using Xilinx Coregen.
;
;
Radix = 10;
Coefficient_Width = 25;
CoefData = -1952,
-1454,
-1968,
-2578,
-3290,
-4107,
-5030,
-6059,
-7188,
-8411,
-9717,
-11091,
-12513,
-13962,
-15410,
-16825,
-18174,
-19416,
-20511,
-21413,
-22077,
-22453,
-22494,
-22153,
-21383,
-20141,
-18390,
-16095,
-13229,
-9775,
-5723,
-1073,
4162,
9958,
16276,
23066,
30262,
37786,
45545,
53434,
61334,
69117,
76646,
83773,
90349,
96219,
```

101230,
105230,
108074,
109626,
109761,
108373,
105373,
100694,
94296,
86164,
76317,
64804,
51707,
37144,
21266,
4260,
-13655,
-32230,
-51186,
-70218,
-89002,
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-184208,
-188565,
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-187535,
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-159375,
-142691,
-122465,
-98864,
-72126,
-42563,
-10554,
23455,
58958,
95390,
132141,
168560,
203967,
237665,
268948,
297118,
321497,
341440,
356350,
365691,
368999,
365900,
356117,
339479,
315935,
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248549,

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-2074707,
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-2271440,
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11287657,
11186521,
11019203,
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10142143,
9735452,
9278476,
8776155,
8233875,
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-84994,
-19718,
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156102,
205242,
248549,
285558,
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-107195,
-89002,
-70218,

-51186,
-32230,
-13655,
4260,
21266,
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51707,
64804,
76317,
86164,
94296,
100694,
105373,
108373,
109761,
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-22494,
-22453,
-22077,
-21413,
-20511,
-19416,
-18174,
-16825,
-15410,
-13962,
-12513,
-11091,
-9717,
-8411,
-7188,
-6059,
-5030,
-4107,

-3290,
-2578,
-1968,
-1454,
-1952;

TECHWAY
SIGNAL VISION SYSTEM

6.2 SNMP configuration script

```
#! /bin/sh

IP=${1:-192.168.0.150}

#System Configuration
echo "########################"
echo "   SYSTEM CONFIGURATION"
echo "########################"
echo "Rack ID"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.2.1.0 i 1

#Network configuration
echo "#########################"
echo "   NETWORK CONFIGURATION"
echo "#########################"
echo "FPGA IP"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.4.1.0 s "10.1.1.1"
echo "IP Destination 0"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.4.2.1.0 s "10.1.1.4"

#Acquisition Configuration
echo "#############################"
echo "   ACQUISITION CONFIGURATION"
echo "#############################"

echo "Sample frequency"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.2.9.0 i 1000000
echo "Capture mode: Rising Edge trigger"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.2.6.0 i 0
echo "Trigger Level: LVPECL"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.2.7.0 i 1

#Process configuration
echo "###########################"
echo "   PROCESSING CONFIGURATION"
echo "###########################"

echo "DDS frequencies"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.1.1.0  i 69000000 # 1 MHz
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.2.1.0  i 68000000 # 4 MHz
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.3.1.0  i 67500000 # 4.5 MHz
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.4.1.0  i 67000000 # 5 MHz
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.5.1.0  i 65000000 # 10 MHz
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.6.1.0  i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.7.1.0  i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.8.1.0  i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.9.1.0  i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.10.1.0 i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.11.1.0 i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.12.1.0 i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.13.1.0 i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.14.1.0 i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.15.1.0 i 10000000
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.16.1.0 i 10000000

echo "Channel/PU mapping"
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.1.6.0  i 0 #Analog input 0
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.2.6.0  i 0
```

```
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.3.6.0  i 0
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.4.6.0  i 0
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.5.6.0  i 0
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.6.6.0  i 16 #16 means OFF
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.7.6.0  i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.8.6.0  i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.9.6.0  i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.10.6.0 i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.11.6.0 i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.12.6.0 i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.13.6.0 i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.14.6.0 i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.15.6.0 i 16
snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.16.6.0 i 16

#Filters configuration
echo "##########################"
echo "   FILTERS CONFIGURATION"
echo "##########################"

# Additional decimation setting
for pu_num in $(seq 1 1 5) ; do
  echo "DDC additional_decimation setting"
  additional_decimation=2
  snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.7.0 i ${additional_decimation}

# FIR's coefficient set loading
 echo "FIR coefficient loading"
 coefile=$(cat ../Rebecca_fs_100_MHz_fc_2000_kHz.coe)
 snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.8.0 s "$coefile"

# DDC output width setting
  echo "DDC output width setting"
  ddc_output_width=1
  snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.9.0 i ${ddc_output_width}
done;

# PU windowing configuration
for pu_num in $(seq 1 1 16) ; do
  ###### BYPASS PARAMETER MUST BE SET BEFORE INPUT WINDOW #######
  echo "ByPass"
  snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.3.0 i 0
  echo "Input Window"
  snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.4.0 s "0 160000 4294967295"
  echo "Output Destination"
  snmpset -v 1 -r 0 -t 15 -c public ${IP} 1.3.6.1.4.1.35959.5.2.3.${pu_num}.5.0 s "0 0"
done;
```

6.3 MATLAB design script

```matlab
clc; close all; clear all;


%% System parameters

fs = 100e6;     % Sampling Frequency

% FIR frequency response's parameters
FirDecimFactor = 8;         % Decimation factor
FirOrder       = 410;       % Filter order
FirCutoffFreq  = 2.1e6;     % Stopband Frequency (dB)
Apass          = 0.1;       % Passband Ripple (dB): +/- 0.25 dB
Astop          = 100;       % Stopband Attenuation (dB)

% FIR logical interfaces' parameters
FirInputWidth        = 17; % FIR input width
FirTruncOutputWidth = 32; % FIR truncature output width
FirCoeffWidth        = 25; % FIR coefficients width


%% File paths

% FIR's coe file path creation
FirCoeFilePath = strcat('./coe/Rebecca_fs_',...
                        num2str(fs/1e6),...
                        '_MHz_fc_',...
                        num2str(FirCutoffFreq/1e3),...
                        '_kHz.coe');


%% FIR filter design
FirSpecs = fdesign.decimator(FirDecimFactor, 'Lowpass','n,fc,ap,ast', FirOrder,...
                              FirCutoffFreq, Apass, Astop, fs);

hFIR = design(FirSpecs,'equiripple');
hfvt_norm_fir = fvtool(hFIR, 'Fs', fs);
set(hfvt_norm_fir, 'ShowReference', 'off')
set(hfvt_norm_fir, 'NumberofPoints', 65536)
axes = get(hfvt_norm_fir, 'CurrentAxes');
% set(axes, 'XLim', [0 fs/FirDecimFactor]);
set(axes, 'YLim', [-120 10]);
legend(hfvt_norm_fir, 'FIR normalized response');


%% Fixed-point properties & design

set(hFIR, 'Arithmetic', 'fixed',...
          'InputWordLength', FirInputWidth,...
          'InputFracLength', 0,...
          'CoeffWordLength', FirCoeffWidth,...
          'FilterInternals','FullPrecision');

% Output truncature
OutFirBits      = hFIR.OutputWordLength
OutFracFirBits  = hFIR.OutputFracLength;


hFIRtrunc = dfilt.scalar(2^(FirTruncOutputWidth-(OutFirBits-OutFracFirBits)));
set(hFIRtrunc, 'Arithmetic', 'fixed',...
               'InputWordLength', OutFirBits,...
               'InputFracLength', OutFracFirBits,...
               'OutputMode', 'SpecifyPrecision',...
               'OutputWordLength', FirTruncOutputWidth,...
```

```
                'OutputFracLength', 0,...
                'OverflowMode', 'wrap',...
                'RoundMode', 'round');

% Complete filter (FIR + truncature)
hCompleteFIR = cascade(hFIR, hFIRtrunc);
hfvt_bt_fir = fvtool(hCompleteFIR, 'Fs', fs);
set(hfvt_bt_fir, 'ShowReference', 'off')
set(hfvt_bt_fir, 'NumberofPoints', 65536)
axes = get(hfvt_bt_fir, 'CurrentAxes');
set(axes, 'XLim', [0 5.5]);
% set(axes, 'YLim', [-135 5]);
legend(hfvt_bt_fir, 'FIR bit-true complete response');
```

7 SUPPORT INFORMATION

Should you have any questions or support requests, please feel free to contact TECHWAY.

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