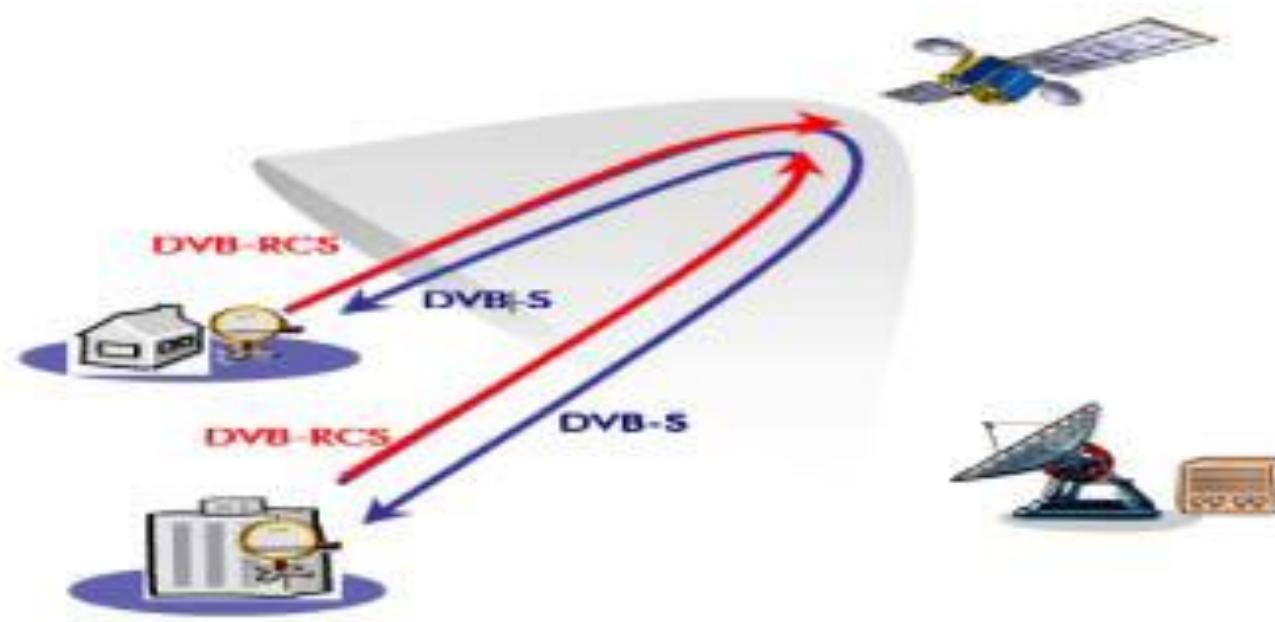
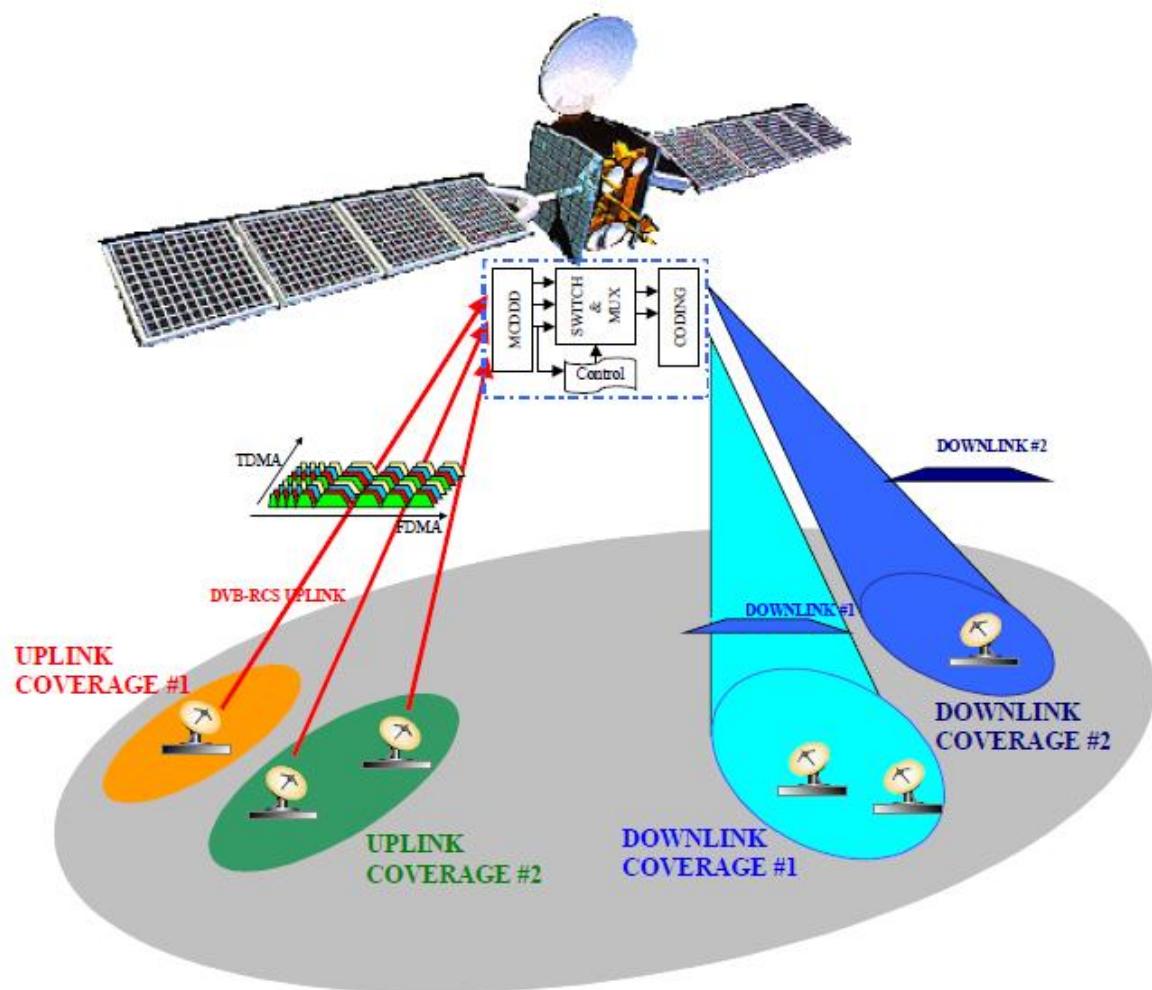
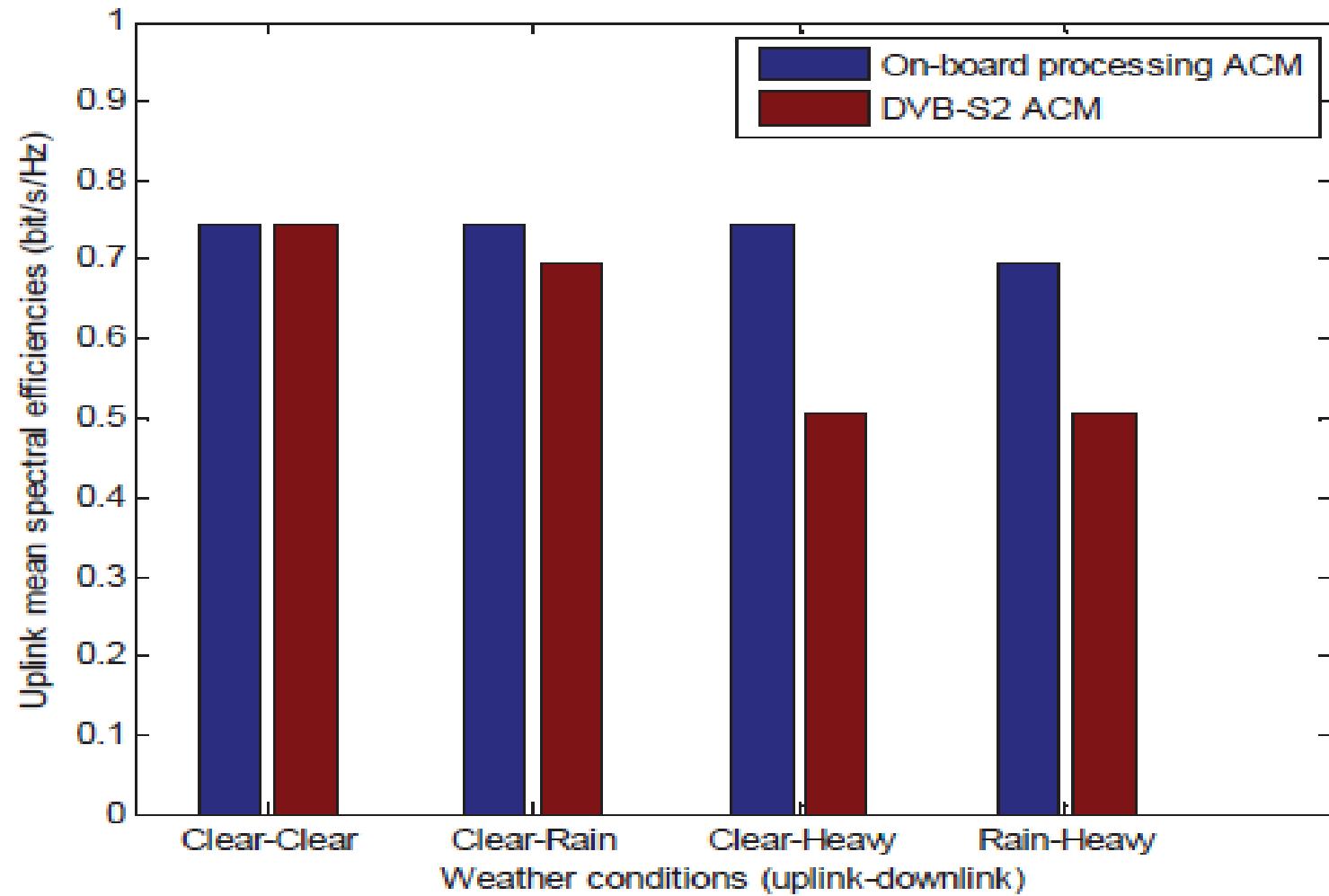


# Design and verification of DVB –RCS TO DVB S2 On-board Processing Payload using Matlab/Simulink



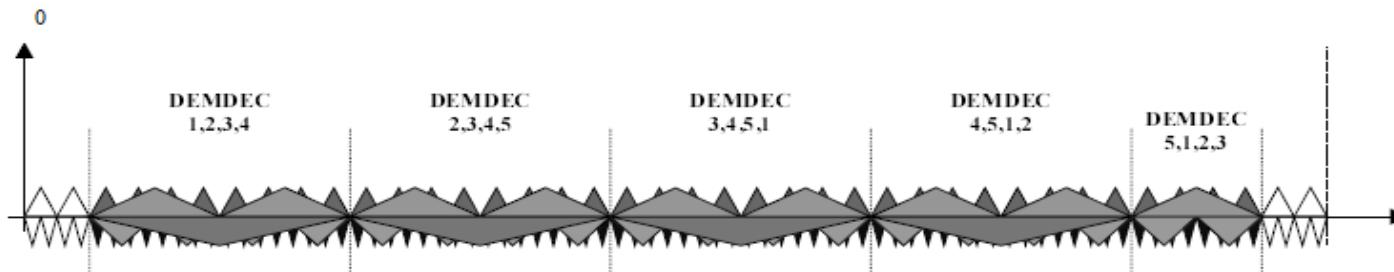
Presented by  
Dr. DEEPAK MISHRA , Scientist/Engineer-SF  
*Digital Communication Division(DCD)*  
*Optical & Digital Communication Group (ODCG)*  
*SPACE APPLICATIONS CENTRE,ISRO*





- Framing : MPEG-2 Transport Stream
- Coding Turbo-Code : (DVB-RCS)
- Modulation : QPSK, roll-off 0.35
- Access : MF-TDMA
- Carrier spacing :  $1.5 k.R_s$  ( $k = 1, 2, 4, 8$  and  $16$ )
- Information data rates :  $k.R_i$  ( $R_i = 0.518$  Mbps and  $k = 1, 2, 4, 8$  and  $16$ )

- Powerful FEC system based on LDPC (Low-Density Parity Check) codes
- Wide range of code rates (from 1/4 up to 9/10)
- New Modulation schemes ranging from 2 to 5 bit/second/Hz spectrum efficiency - QPSK, 8PSK, 16APSK, 32APSK
- Set of three spectrum shapes with roll-off factors 0.35, 0.25 and 0.20
- Flexible stream adapter, suitable to operate with single and multiple TS on the same carrier with different modulation and FEC
- Variable & Adaptive Coding and Modulation (VCM/ACM) functionality, allowing to optimise channel coding and modulation on a frame-by-frame basis



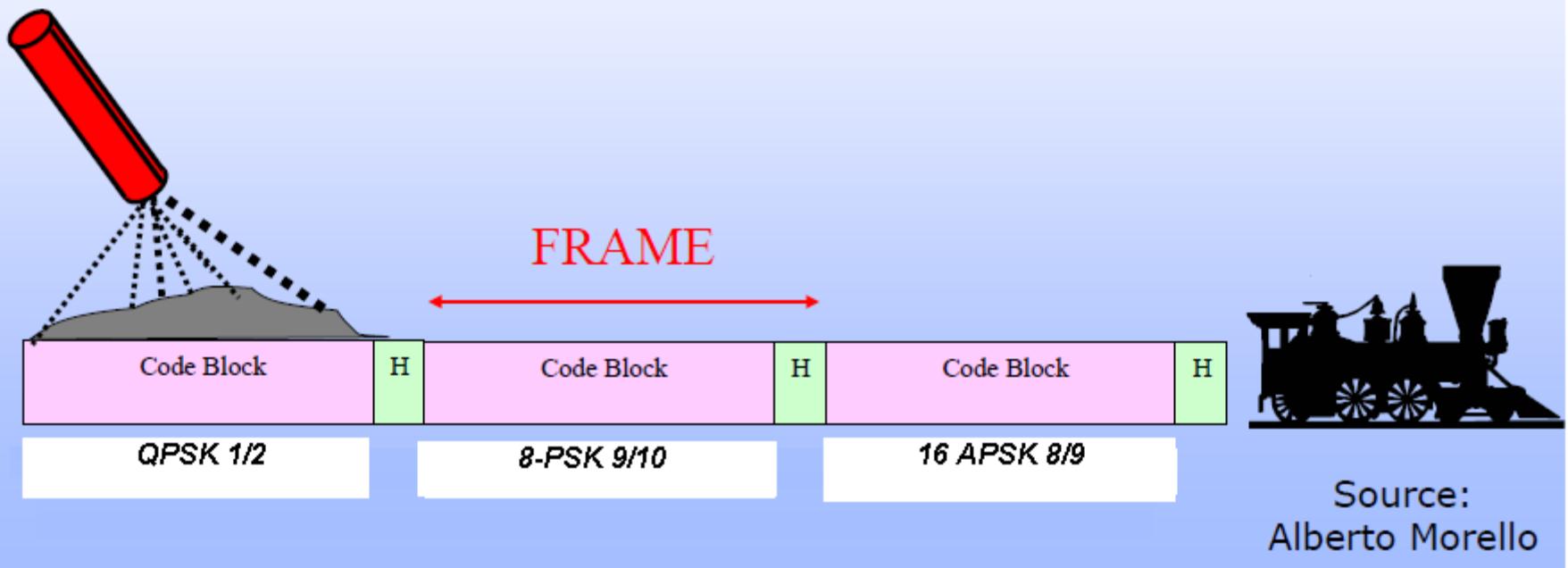
SPECIFICATION	VALUES
Bandwidth	36 MHz Dynamic B.W. allocation 1.5 k.Rs ( $k = 1, 2, 4, 8$ and $16$ )
IF freq.	950-1450 MHz
Framing	MPEG-2 TS /Generic stream
Access Mode	MF-TDMA
User/ Provider Terminal	DVB-RCS Standard
Signal Error Correction	Turbo Code- Rates (4/5)
Modulation	QPSK, $\alpha = 0.35$

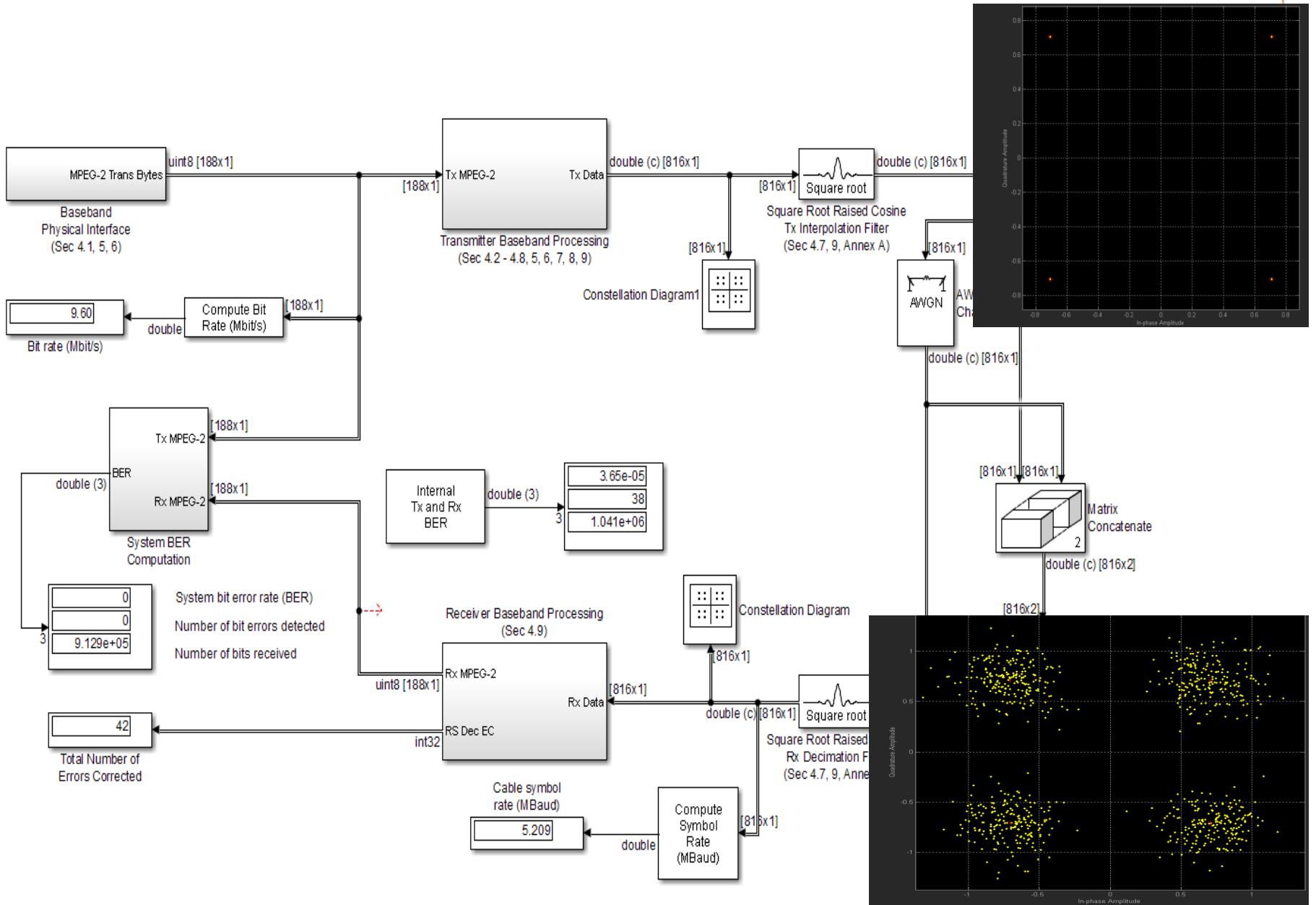
SPECIFICATION	VALUES
IF Freq.	950-2150 MHz (L band)
Access Mode	TDM
DVB-S2 Standard	Yes
Data Rate(MAX)	50 Mbps –rate $\frac{1}{2}$ 28.125 Mbps – rate 8/9 27.78 Mbps– rate 9/10
Coding	LDPC Inner Coding rates QPSK (1/2) 8PSK(9/10) 16APSK(8/9)  With data frame length normal (64800) BCH Outer Coding Bit Interleaving
Modulation Scheme	QPSK, 8PSK, 16APSK $\alpha = 0.20$ CCM, VCM, ACM (on above three MODCOD)
Type of Services	Broadcast – QPSK with $\frac{1}{2}$ coding DSNG(IP based) -- 8 PSK with 9/10 coding Unicast Interactive IP service (ACM mode)-16 APSK with 8/9 Coding

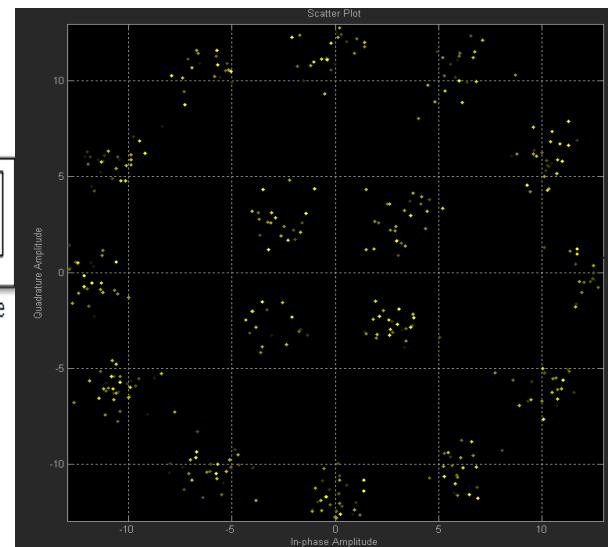
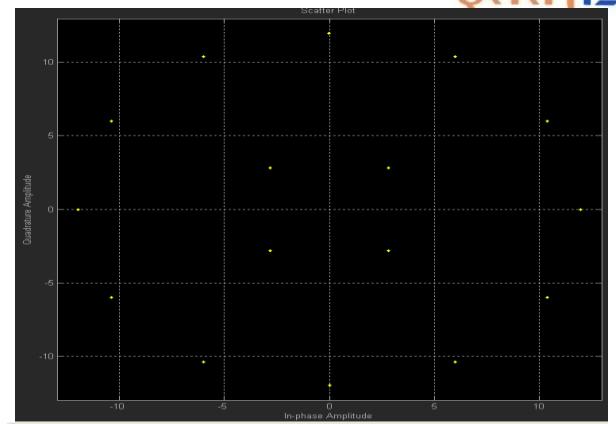
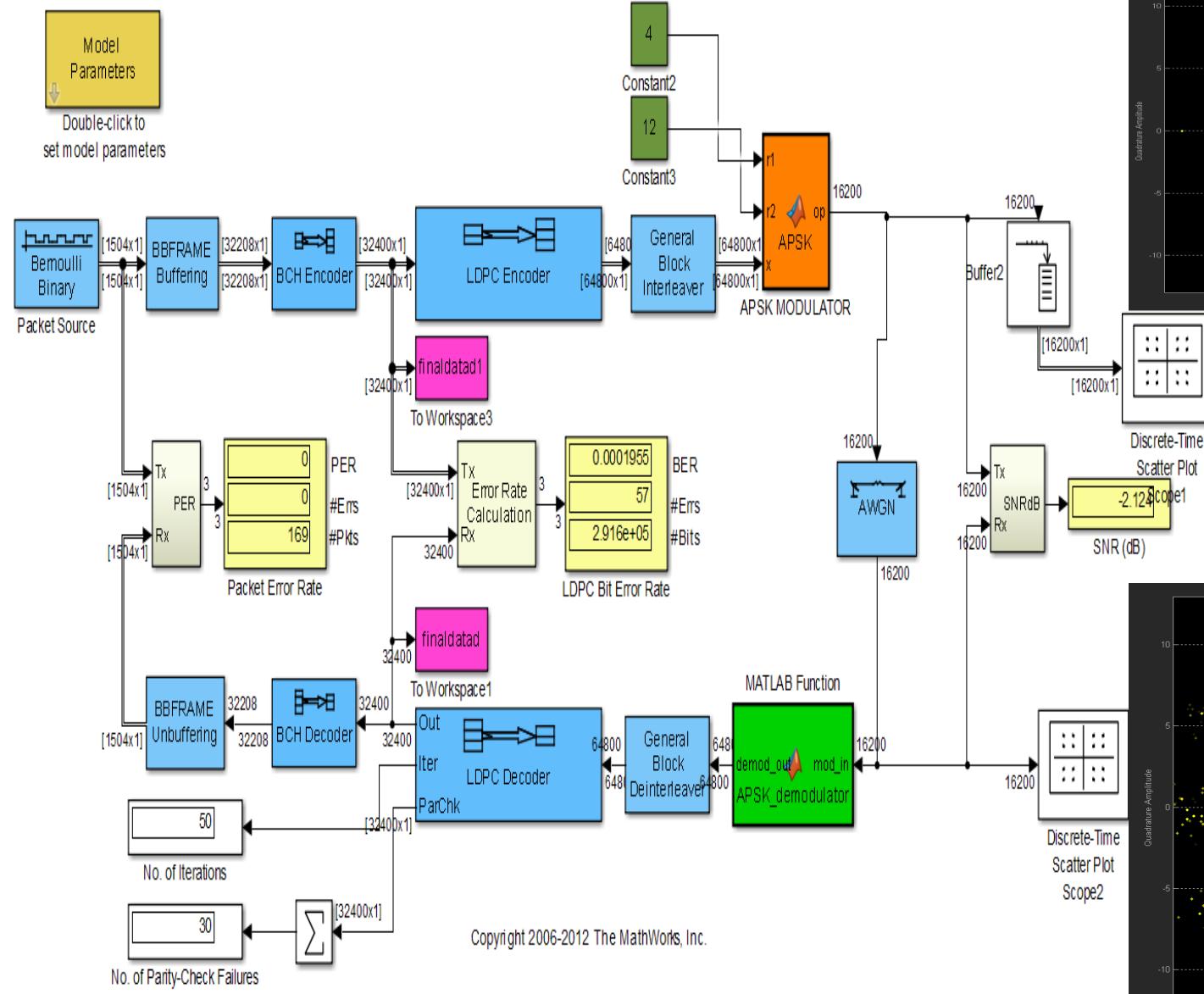


# DVB-S2 Generic Stream

- The transmission is organised in **FRAMES** (train wagons)
  - Each frame transports a **FEC CODE BLOCK** (64800 bit) or (16200 bit).
  - For Adaptive Coding and Modulation (ACM), protection may change frame-by-frame





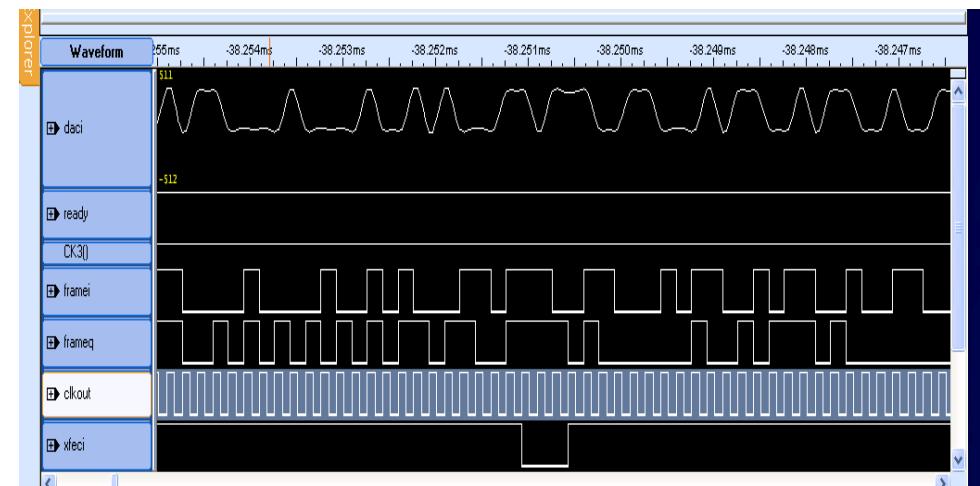


Copyright 2006-2012 The MathWorks, Inc.

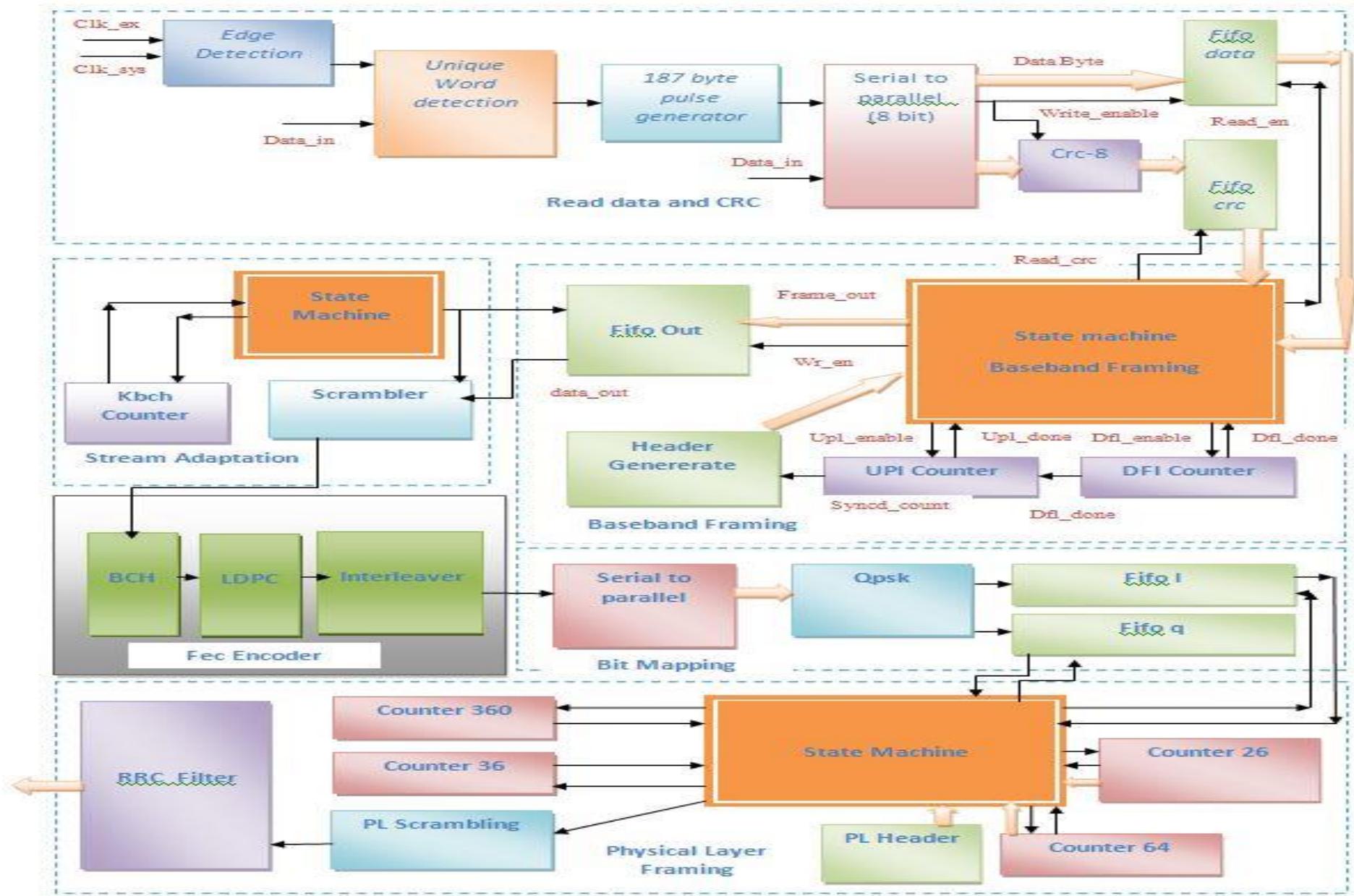
## CCM Mode Implementation

- **Input Interface**
  - MPEG-2 TS : 188 bytes
  - CRC-8 :  $X^8 + X^7 + X^6 + X^4 + X^2 + 1$
- **Baseband Framing and Header insertion**
  - DFL : 32208 bits (Fixed for  $\frac{1}{2}$  Code rate)
- **Stream Adaptation**
  - Zero Padding : off for transport stream
  - Baseband scrambling
- **FEC Encoder**
  - BCH
  - LDPC (code rate :1/2)
  - Interleaver
- **Bit mapping**
  - QPSK
- **Physical Layer Framing and Scrambling**
  - PL header : 90 symbols
    - SOF
    - MODCOD
  - Dummy Frame Insertion : (36 slots Un-modulated)
  - PLFRAME : QPSK data 360 slots (1 slot=90 symbols)
- **RRC Filter**
  - 0.20 roll-off

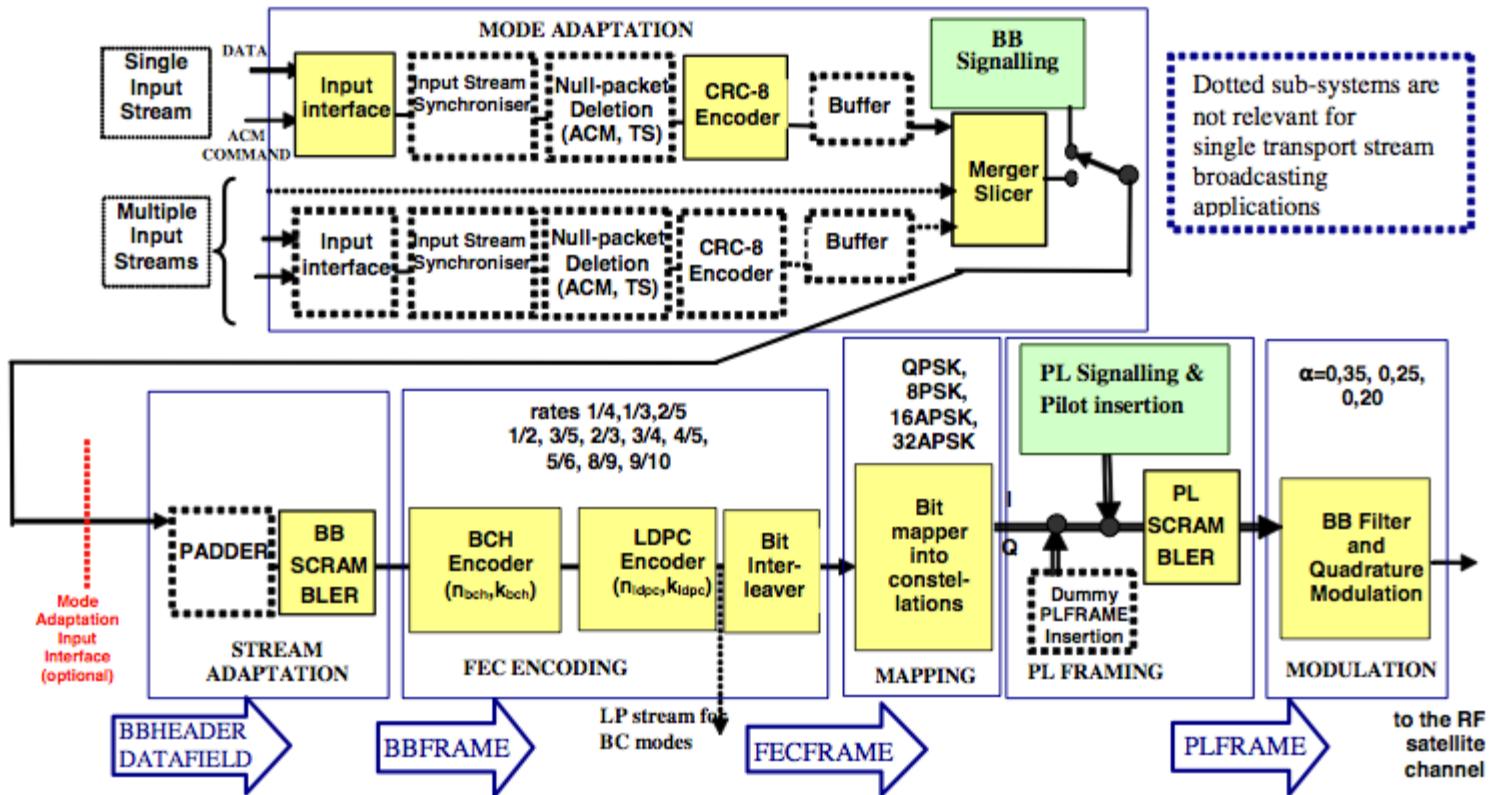
FPGA : XC5VFX130T



# Implementation Diagram



# Implementation Diagram



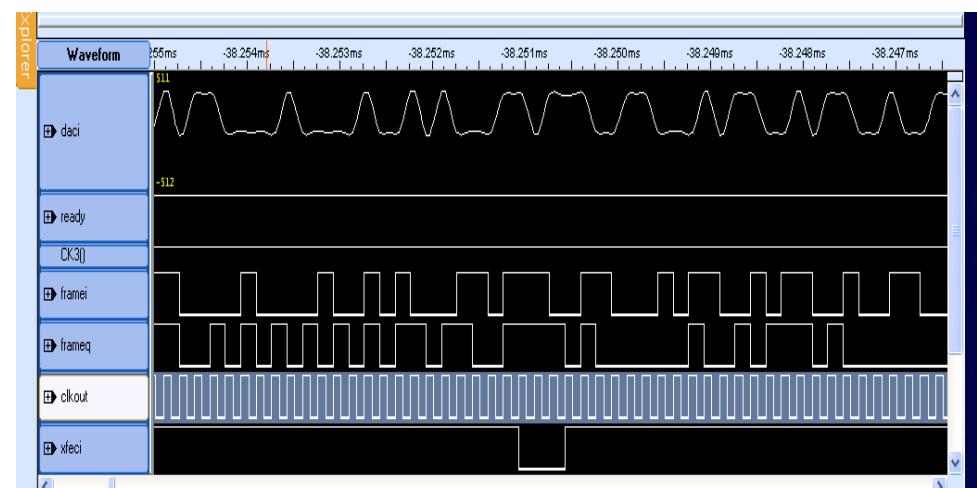
DVBS2 Functional Block Diagram

(Courtesy: ETSI EN 302307)

# CCM Mode Implementation

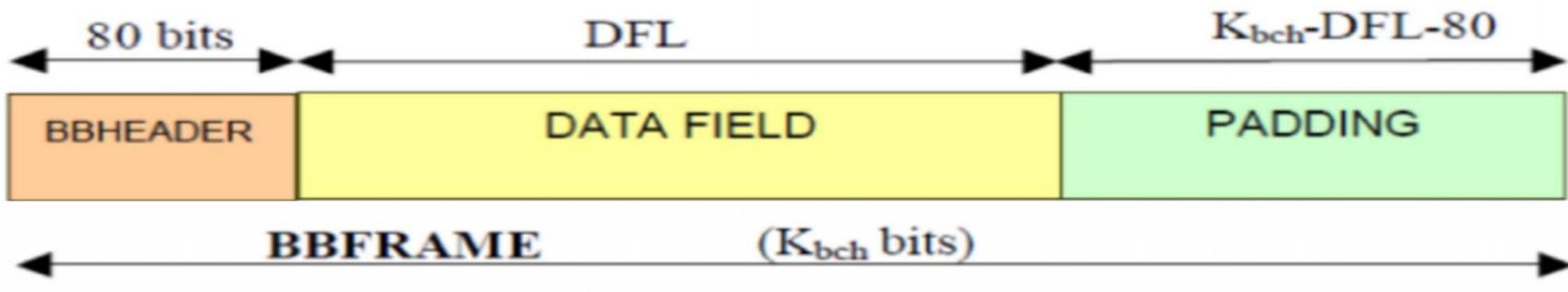
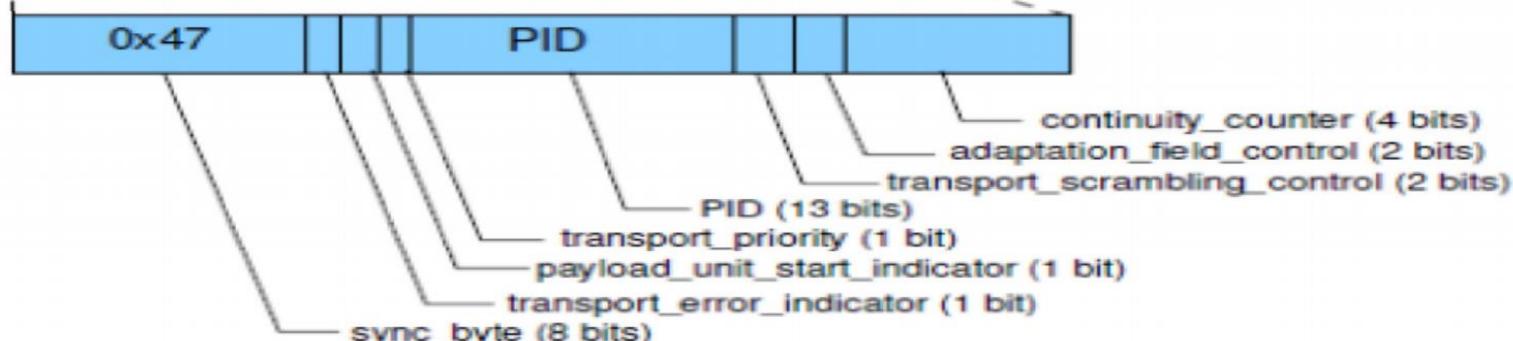
- **Input Interface**
  - MPEG-2 TS : 188 bytes
  - CRC-8 :  $X^8 + X^7 + X^6 + X^4 + X^2 + 1$
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  - Baseband scrambling
- **FEC Encoder**
  - BCH
  - LDPC (code rate :1/2)
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- **Bit mapping**
  - QPSK
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  - PL header : 90 symbols
    - SOF
    - MODCOD
  - Dummy Frame Insertion : (36 slots Un-modulated)
  - PLFRAME : QPSK data 360 slots (1 slot=90 symbols)
- **RRC Filter**
  - 0.20 roll-off

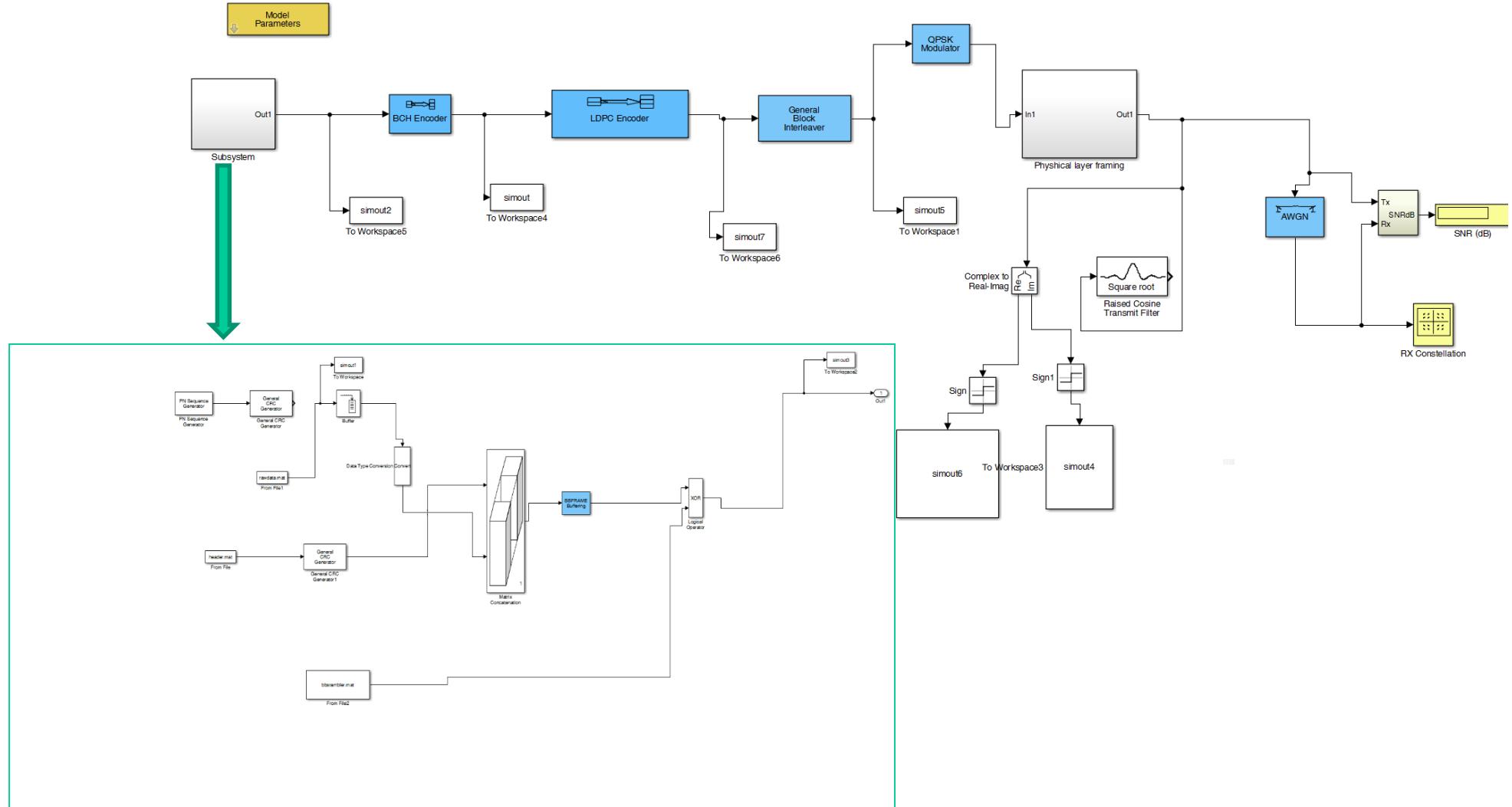
FPGA : XC5VFX130T



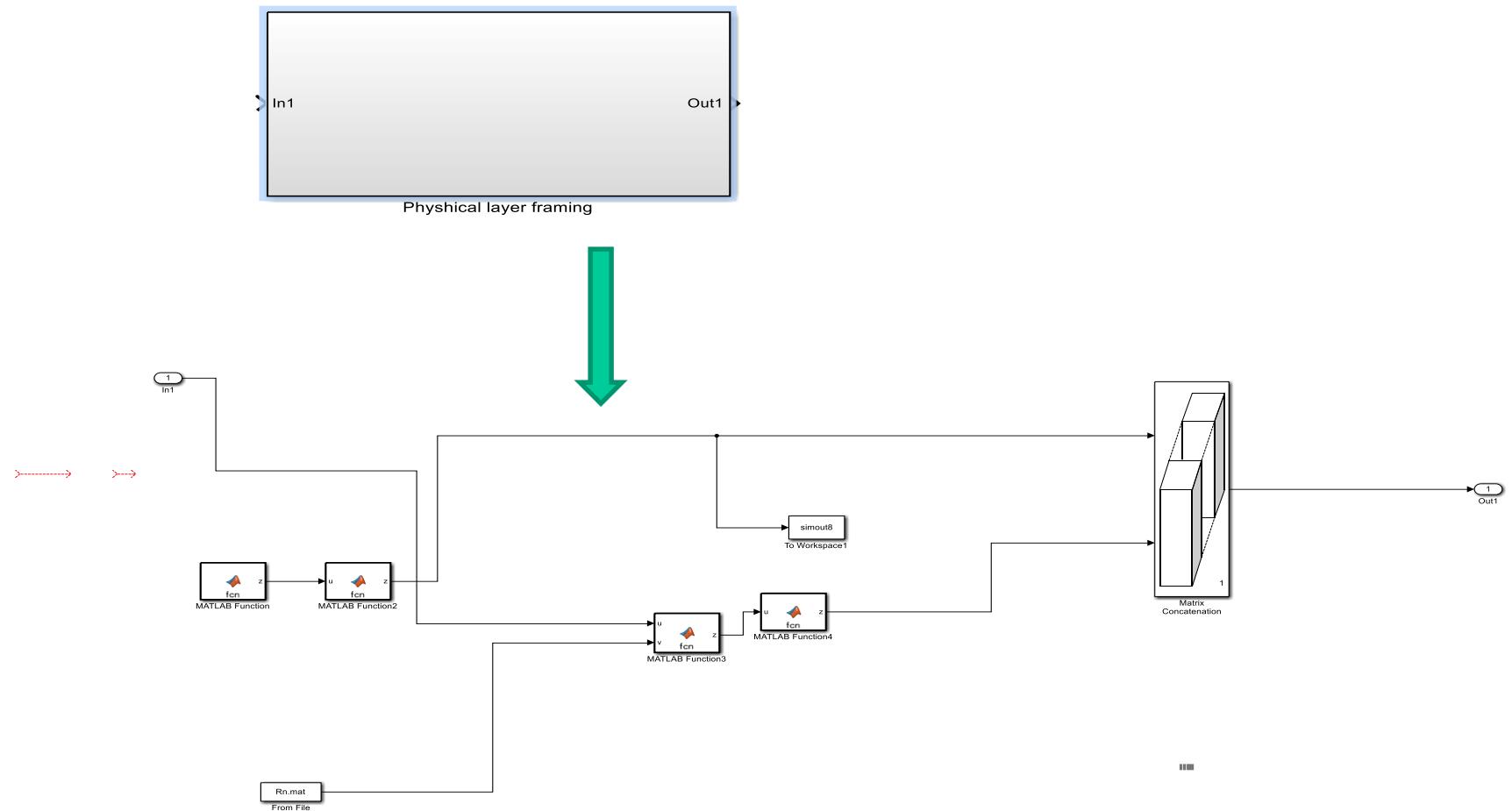


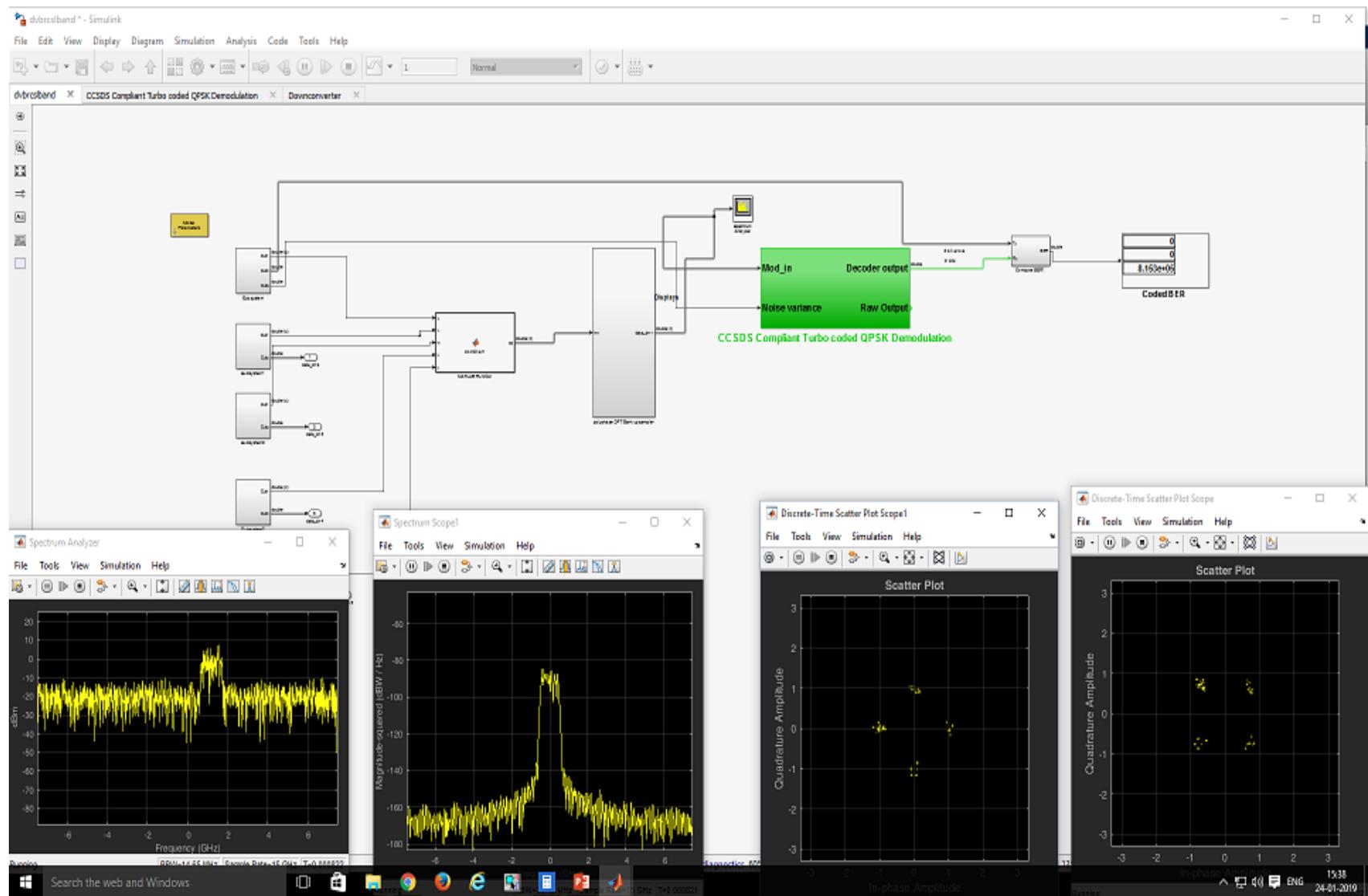
Transport Stream Packet – 188 bytes

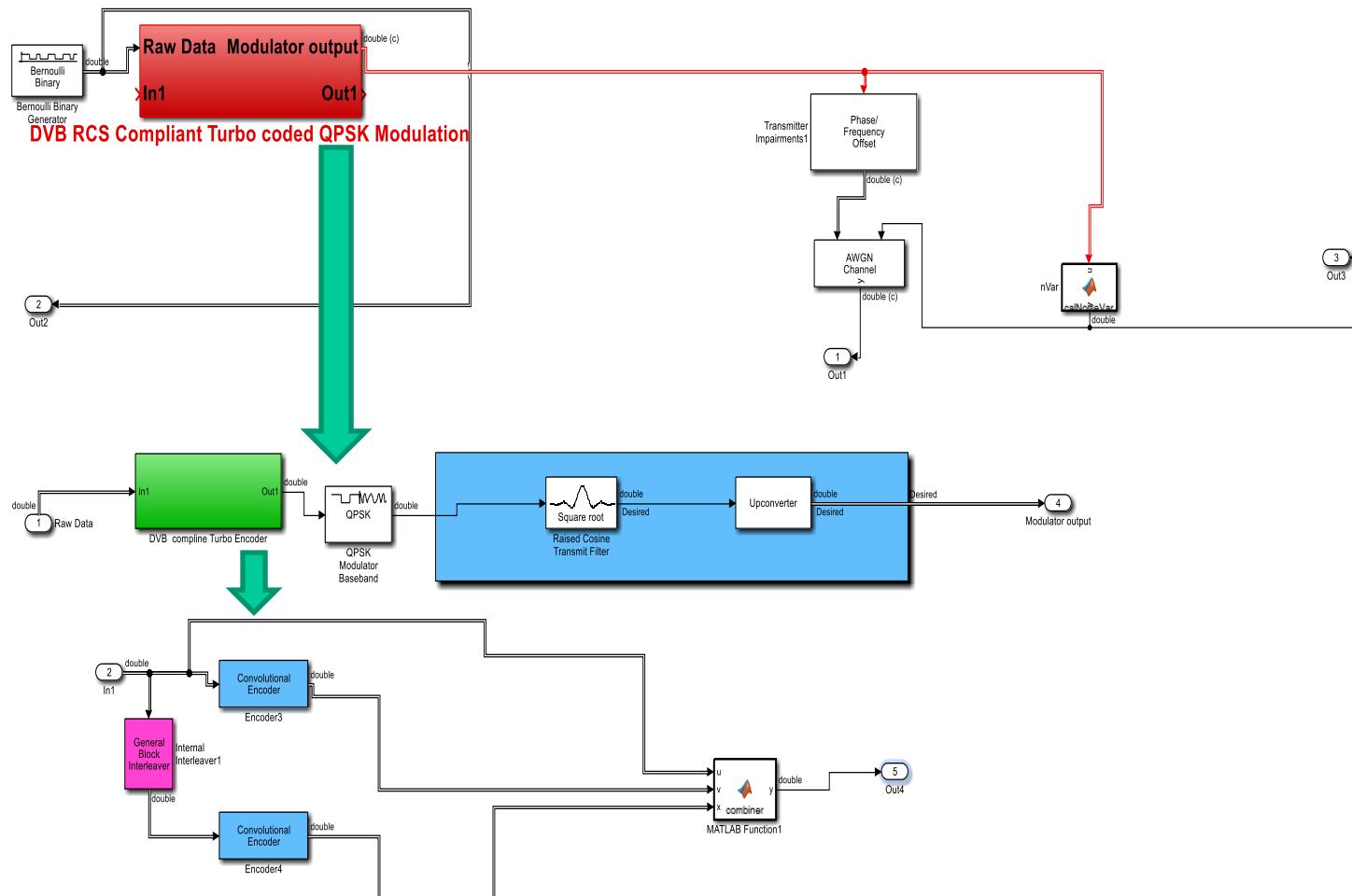




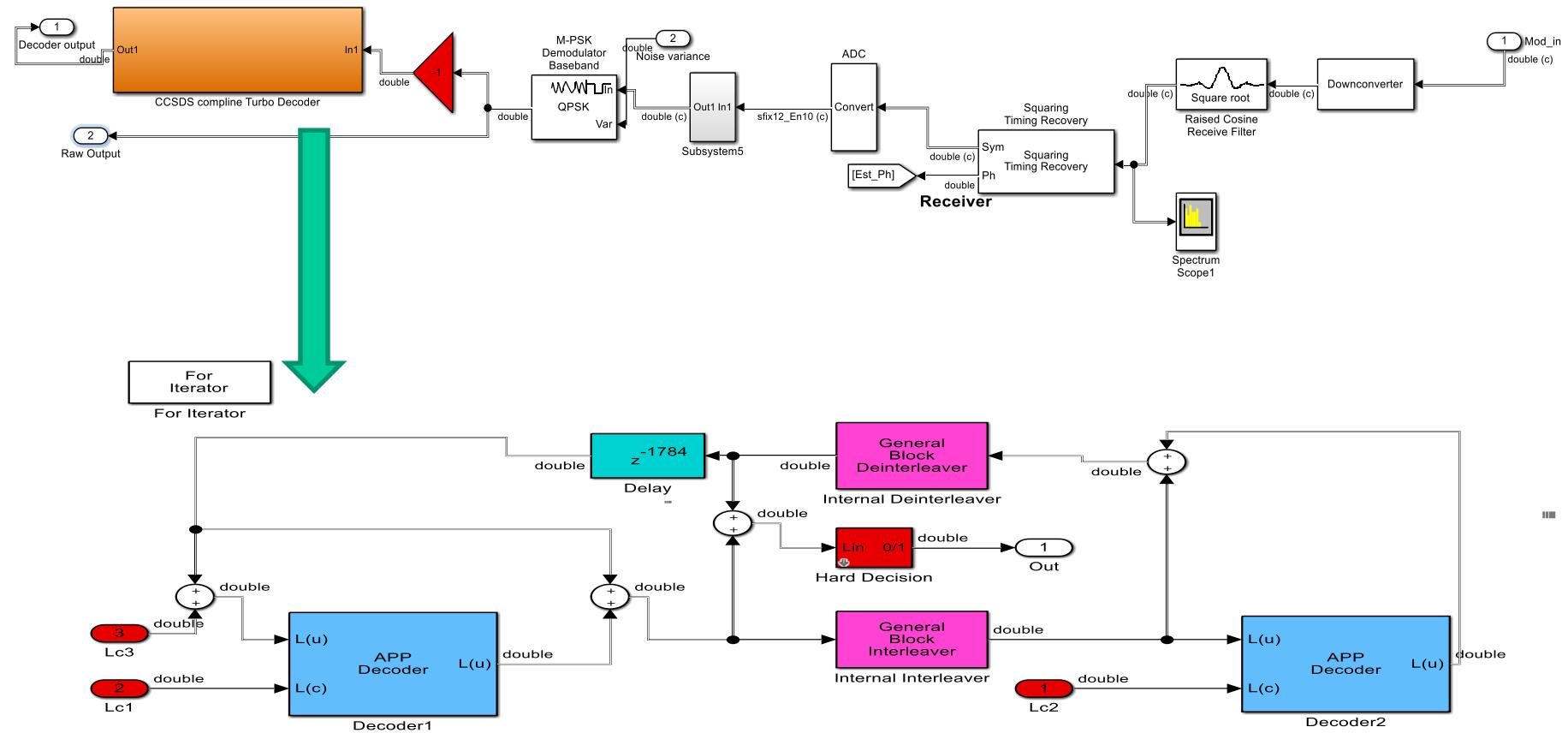
# DVB S2 Baseband Frame Generation



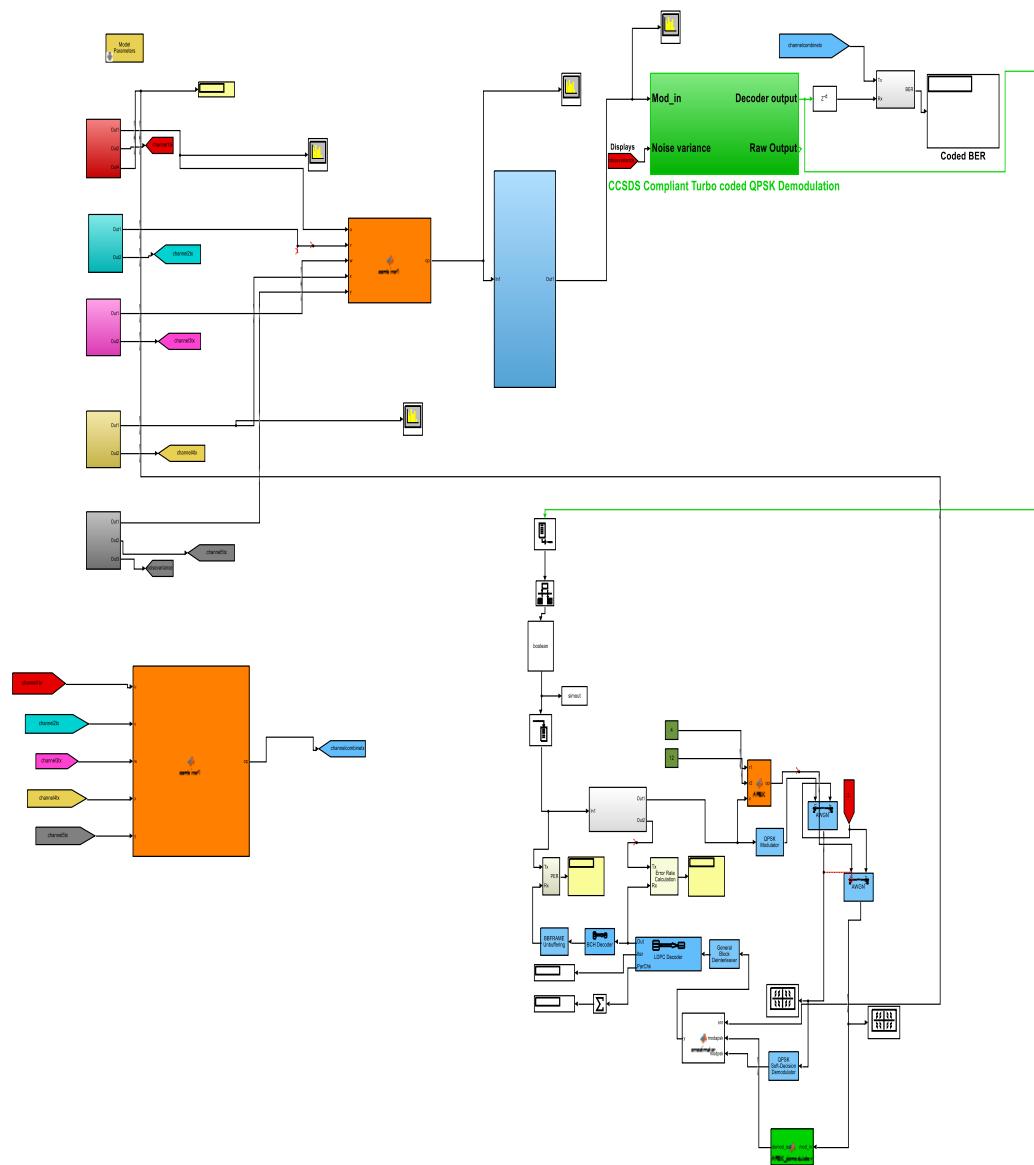


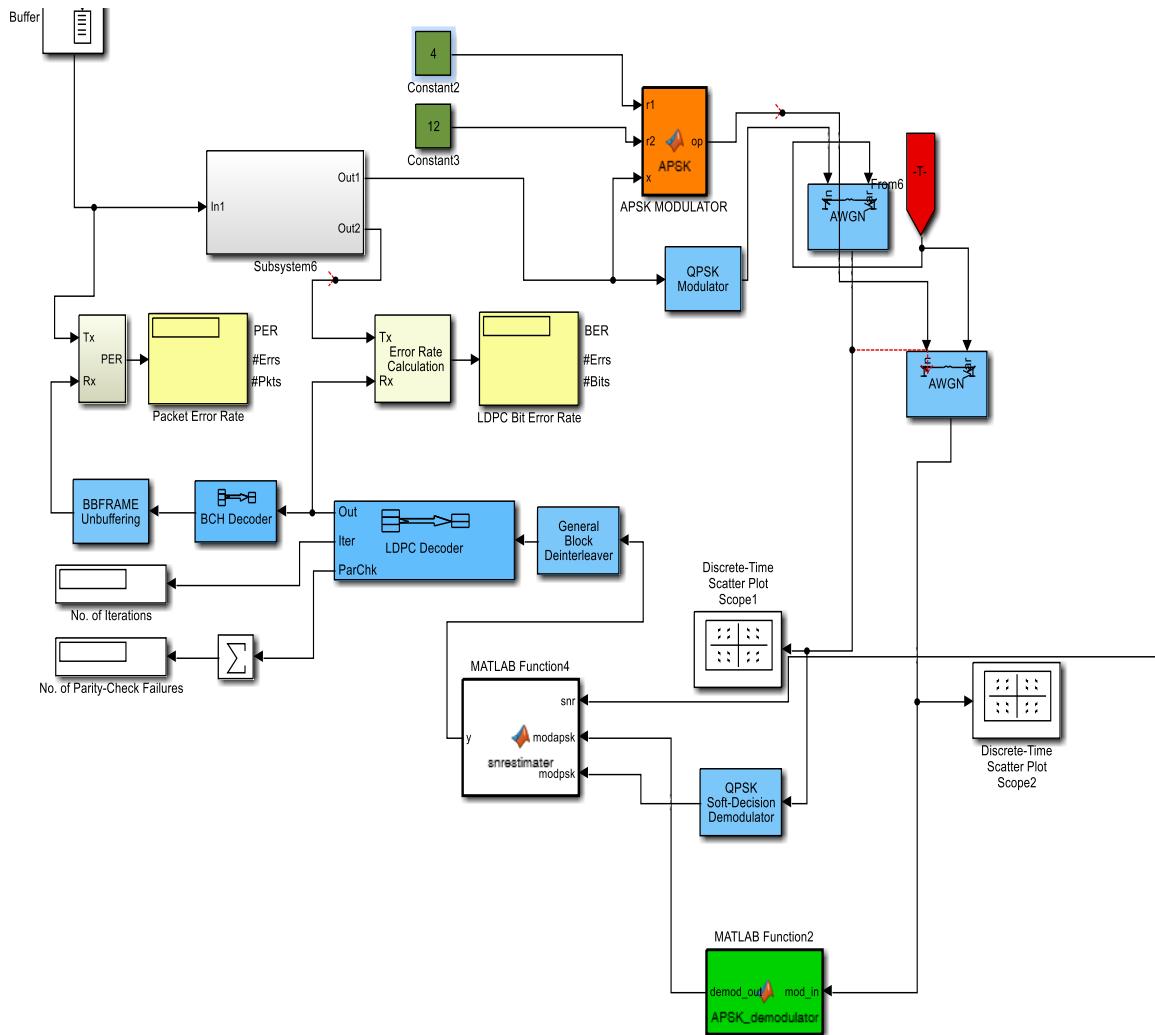


# DVB-RCS UPLINK SIMULATION

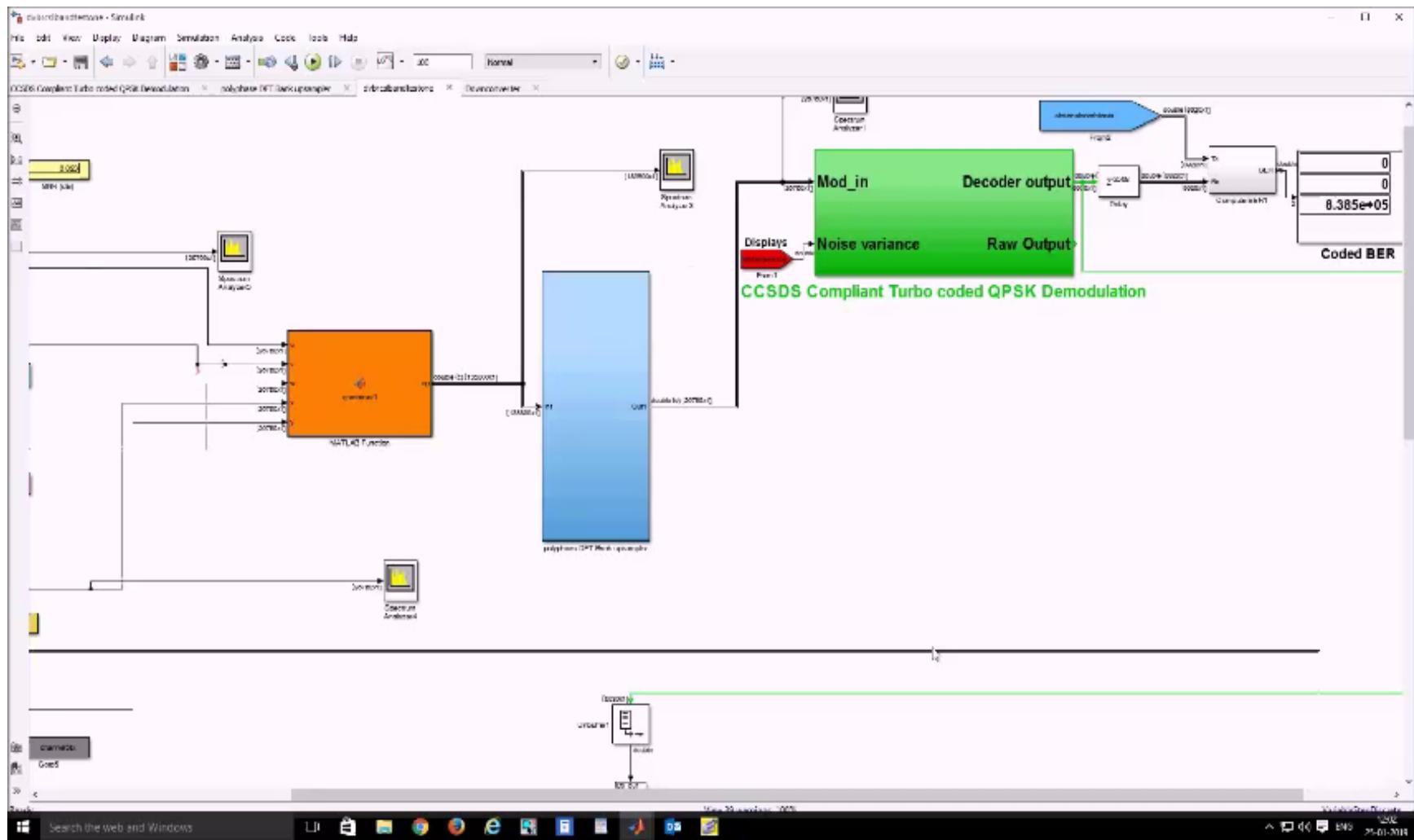


# Combined Simulation



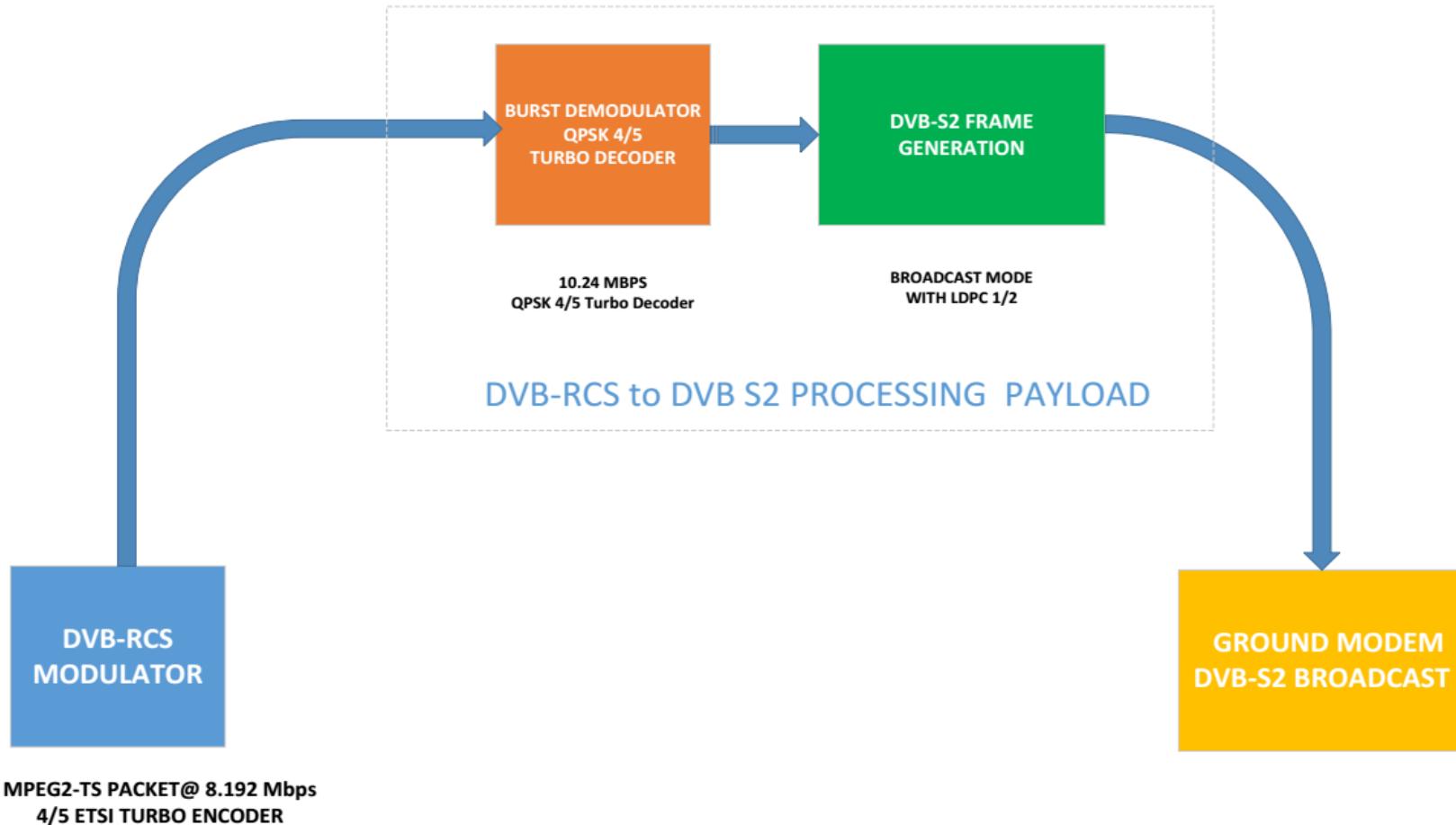


# End to End Simulation



❖ Hardware development:

- End to End demonstrations is completed as per following  
..



## **DVB-RCS to DVB S2 POWER ESTIMATION RESULTS:-**

S. NO.	input frequency	input power level	output power level	clk	PRBS	symbol rate	modulation type	C/N	Eb/No
1	10.23 MHz	0 dBm	-16.93	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
2	10.23 MHz	-1 dBm	-16.94	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
3	10.23 MHz	-2 dBm	-18.01	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
4	10.23 MHz	-3 dBm	-19.78	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
5	10.23 MHz	-4 dBm	-21.72	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
6	10.23 MHz	-5 dBm	-23.43	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
7	10.23 MHz	-6 dBm	-25.36	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
8	10.23 MHz	-7 dBm	-27.29	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
9	10.23 MHz	-8 dBm	-29.31	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
10	10.23 MHz	-9 dBm	-31.45	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
11	10.23 MHz	-10 dBm	-33.33	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
12	10.23 MHz	-11 dBm	-35.42	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
13	10.23 MHz	-12 dBm	-37.31	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
14	10.23 MHz	-13 dBm	-39.45	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
15	10.23 MHz	-14 dBm	-41.21	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
16	10.23 MHz	-15 dBm	-43.37	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
17	10.23 MHz	-16 dBm	-45.36	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
18	10.23 MHz	-17 dBm	-47.27	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
19	10.23 MHz	-18 dBm	-49.34	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
20	10.23 MHz	-19 dBm	-51.46	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB
21	10.23 MHz	-20 dBm	-53.48	131.072	PRBS 23	1 Mbps	QPSK	10.99 dB	14 dB

## DVB-RCS to DVB S2 POWER ESTIMATION RESULTS:-

when noise power toggled:

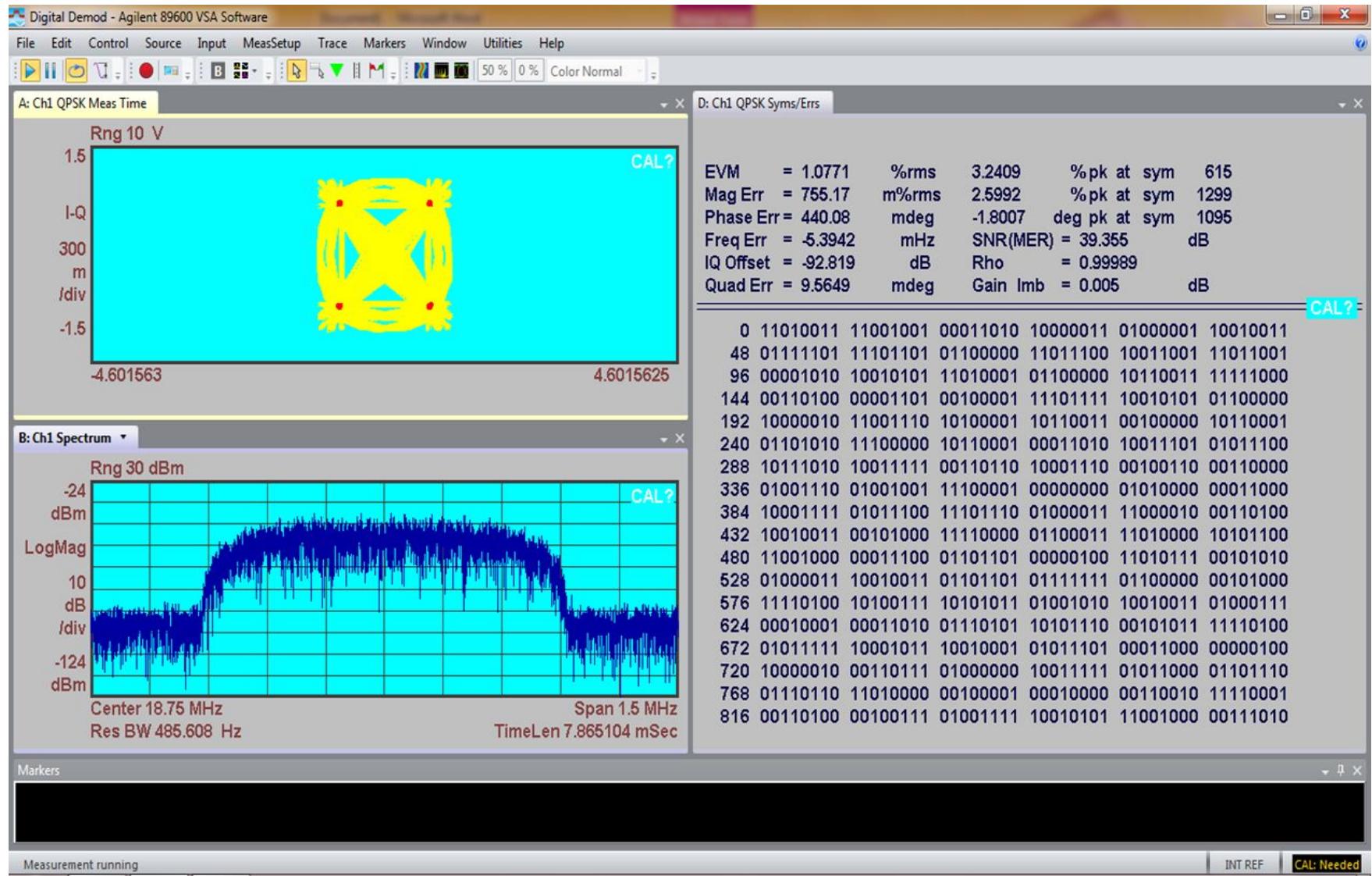
S. NO.	input frequency	Input Eb/N0	C/N	output power level	PRBS	symbol rate	modulation type	clk	input power level
<u>1</u>	<u>10.23 MHz</u>	<u>3 dB</u>	<u>-0.01</u>	<u>-20.83</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>2</u>	<u>10.23 MHz</u>	<u>4 dB</u>	<u>0.99</u>	<u>-20.35</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>3</u>	<u>10.23 MHz</u>	<u>5 dB</u>	<u>1.99</u>	<u>-19.98</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>4</u>	<u>10.23 MHz</u>	<u>6 dB</u>	<u>2.99</u>	<u>-19.64</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>5</u>	<u>10.23 MHz</u>	<u>7 dB</u>	<u>3.99</u>	<u>-19.37</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>6</u>	<u>10.23 MHz</u>	<u>8 dB</u>	<u>4.99</u>	<u>-18.99</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>7</u>	<u>10.23 MHz</u>	<u>9 dB</u>	<u>5.99</u>	<u>-18.65</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>8</u>	<u>10.23 MHz</u>	<u>10 dB</u>	<u>6.99</u>	<u>-18.19</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>9</u>	<u>10.23 MHz</u>	<u>11 dB</u>	<u>7.99</u>	<u>-17.95</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>10</u>	<u>10.23 MHz</u>	<u>12 dB</u>	<u>8.99</u>	<u>-17.45</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>11</u>	<u>10.23 MHz</u>	<u>13 dB</u>	<u>9.99</u>	<u>-17.11</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>12</u>	<u>10.23 MHz</u>	<u>14 dB</u>	<u>10.99 dB</u>	<u>-16.94</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>13</u>	<u>10.23 MHz</u>	<u>15 dB</u>	<u>11.99 dB</u>	<u>-16.61</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>14</u>	<u>10.23 MHz</u>	<u>16 dB</u>	<u>12.99 dB</u>	<u>-16.44</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>15</u>	<u>10.23 MHz</u>	<u>17 dB</u>	<u>13.99 dB</u>	<u>-16.26</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>16</u>	<u>10.23 MHz</u>	<u>18 dB</u>	<u>14.99 dB</u>	<u>-16.15</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>17</u>	<u>10.23 MHz</u>	<u>19 dB</u>	<u>15.99 dB</u>	<u>-16.02</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>
<u>18</u>	<u>10.23 MHz</u>	<u>20 dB</u>	<u>16.99 dB</u>	<u>-15.98</u>	<u>PRBS 23</u>	<u>1 Mbps</u>	<u>QPSK</u>	<u>131.072</u>	<u>0 dBm</u>

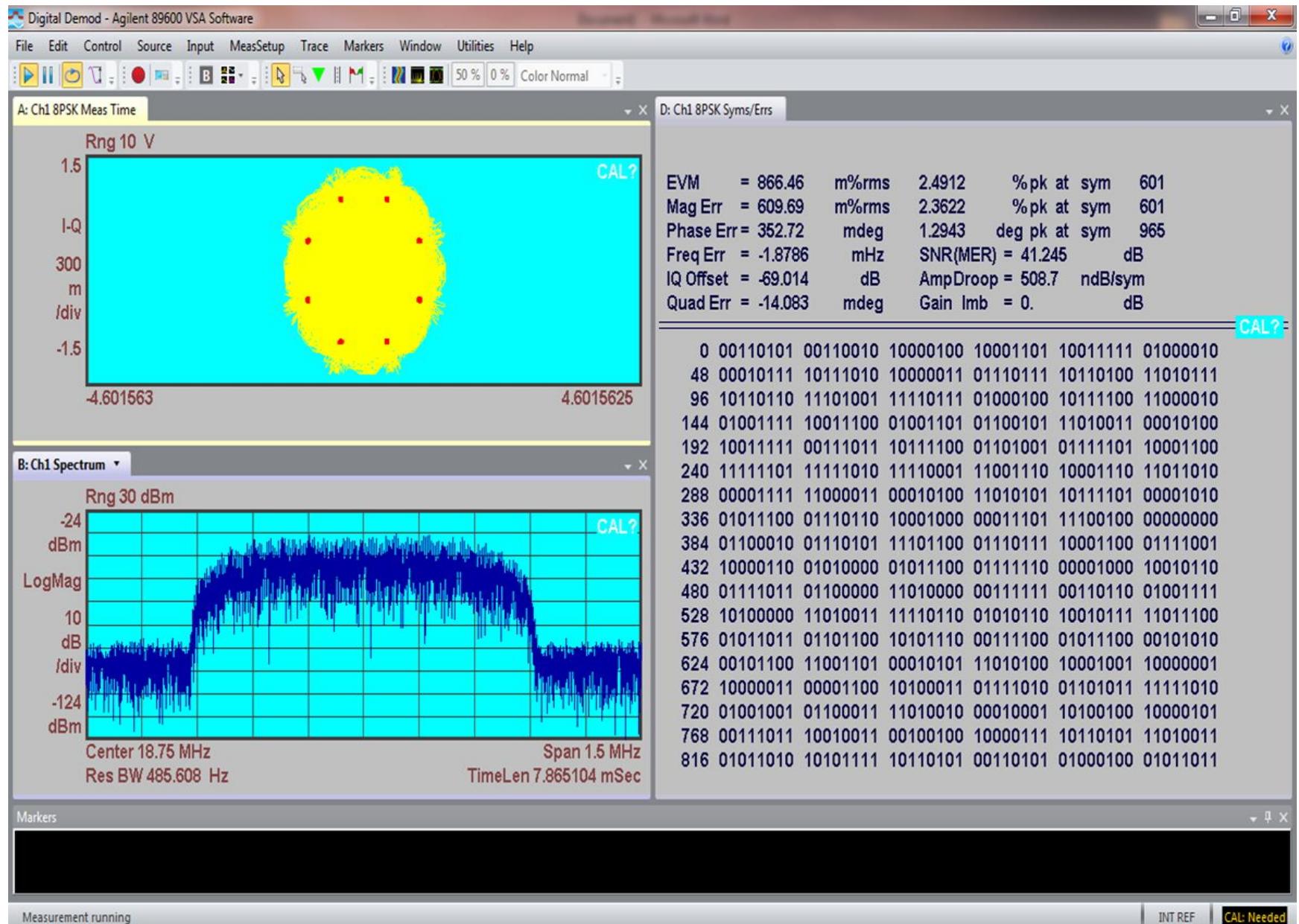
## Key features

- ❖ Complete digital implementation.
- ❖ 2x clock required of RRC filter.
- ❖ Alpha can be .05 to .75.
- ❖ With  $\sin x / x$  equalization .
- ❖ No data rate limitation.

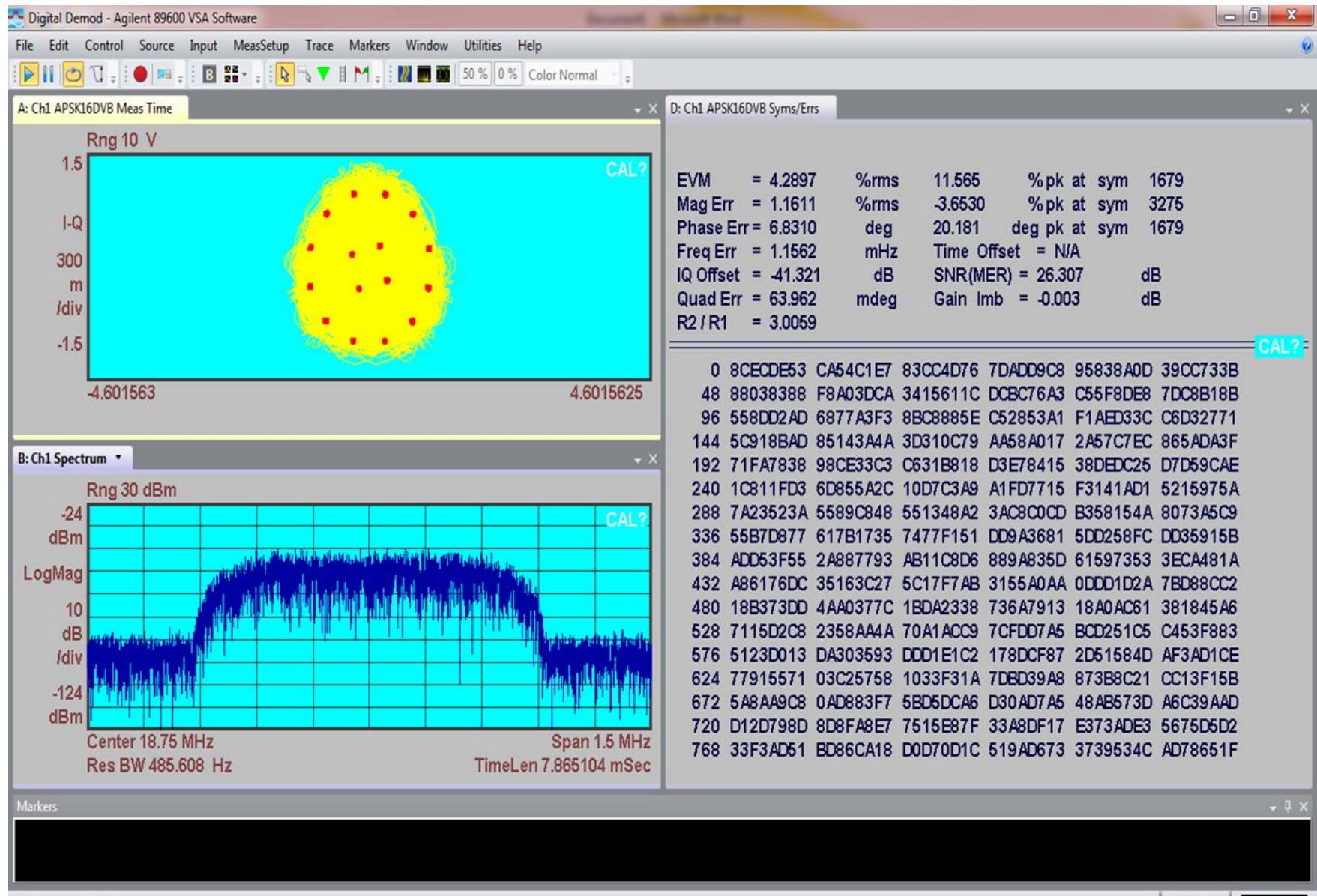
## Comparison of Methodology for RRC

Sr. No.	Parameter	MATLAB	Purposed design
1.	Filter design Approach	Window	Frequency Sampling
2.	Sampling frequency requirement	> data rate	$\geq$ data rate
3.	Roll off	Any value	Any value
4.	Design parameter	<ul style="list-style-type: none"> <li>• Filter order</li> <li>• Window</li> <li>• Sampling frequency</li> <li>• Cutoff frequency</li> <li>• Bandwidth/roll-off</li> </ul>	<ul style="list-style-type: none"> <li>• Filter order</li> <li>• IDDFT length</li> <li>• Data rate</li> <li>• Bandwidth</li> <li>• roll-off</li> </ul>
5.	design parameter control	<ul style="list-style-type: none"> <li>• No direct control over passband and stopband frequency</li> <li>• No Separate control over bandwidth and roll off</li> </ul>	<ul style="list-style-type: none"> <li>• Precise control over passband and stopband frequency</li> <li>• No Separate control over bandwidth and roll off</li> </ul>
6.	Gibbs phenomena	Observed	No
7.	Sine(x)/x equalization	Separate filter design requirement	Integrated with in the purposed code





# 16-APSK Modulation



S300VS2 Management Console V6.3.0.0

File Control Video Wizard Help

Interfaces

- Network
- Satellite
- CAM

IP Data

- Content
- IP Remap

Programs

- Content
- PAT

Control

- Reboot

Selected Device S300VS2 -> IP: 10.61.124.12 MAC: 00-06-76-05-06-bb

Status Signal Data CA Module LNB

Signal Strength -18 dBm

DVBS2 Signal Parameters

- Carrier Freq. 983 MHz (-6 kHz)
- Symbol Rate 7.680 Msps
- MODCOD 1/2 QPSK

Signal Quality

- Uncorrectables 3186
- LDPC BER 0.000e+000
- Carrier to Noise 35.4 dB

Ethernet

- Total Ethernet Packets Sent 18
- Total Ethernet Packets Received 92
- Ethernet Receive Errors 0

DVB

- DVB Packets Accepted 63720
- MPE Packets Processed 0

- ETSI based (DVB RCS) TURBO Encoder and Decoder .
- DVB S2 based LDPC  $\frac{1}{2}$  LDPC Encoder.
- Feed –forward based Burst demodulator.
- DVB-S2 based Frame Formatter.
- DVB S2 based physical layer Scrambler.
- 2x clock based RRC filter
- All DVB S2 based Modulation Scheme.
- Turbo coded 4/5 QPSK burst modulator.



*Dr. Deepak Mishra*

**Scientist/Engineer -SF**

*Digital Communication Division(DCD)*

*Optical & Digital Communication Group (ODCG)*

*deepakmishra@sac.isro.gov.in*

**Space Applications Centre  
Indian Space Research Organization  
Ahmedabad**

**THANK YOU**