NovelSat DUET Technology

Application Note

Version 1.1

July 2014

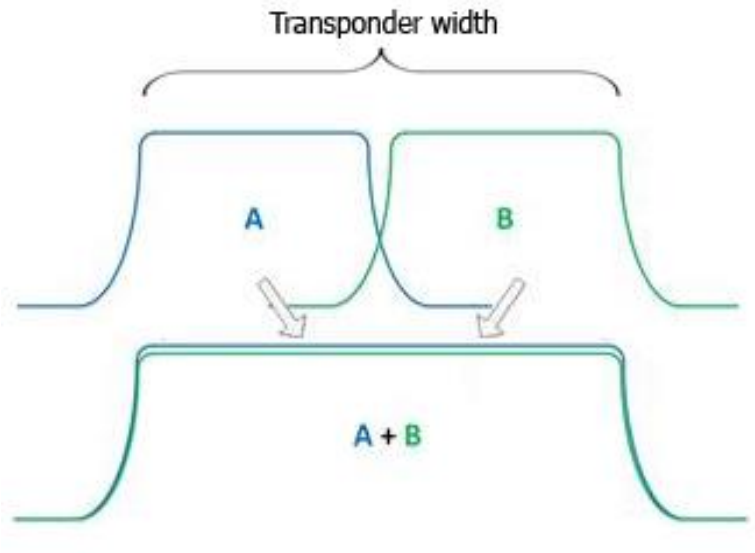
NovelSat USA: 25 Tanglewood Rd. Newton, MA 02459

Contents

1 NovelSat DUET Technology – Preview and Parameters

The unique algorithm and implementation of NovelSat DUET Echo Cancellation technology provide the following advantages:

- Low implementation loss (<0.01dB)
- Built in (no external HW – only license)
- No additional delay.
- Large dynamic range (for asymmetric links)
- Carrier cancellation of 29dB
- Support Outbound/Inbound ratio of ± 10dB (as much as 16 dB in lab tests)



NovelSat DUET Utilization of the Transponder

To illustration how NovelSat DUET utilizes the transponder, let us examine two scenarios:

1. Symmetrical link – Where both earth stations have the same antenna and the same data rate is transmitted from both stations
2. Asymmetrical link – Where each earth station has different antenna, different bit rate, or both

2 Symmetrical links

2.1 Symmetrical link case without NovelSat DUET

For the symmetrical link, let us assume the following scenario.

A 36MHz transponder with a maximal EIRP of 40dBW, divided into two earth stations, each one having 18MHz, will require 37dBW EIRP from the satellite, per carrier.

The total power is divided equally between two earth stations, thus, it is 3dB down from the maximal transponder power.

Next, an SNR of 13dB for each signal is assumed at the receiving side (with required 2dB link margin). Thus, it yields a CNR of 10.79dB and Eb/No of 6.10dB, allowing a MODCOD of 16APSK 4/5, yielding 52.97Mbps per each direction (highlighted below).

The total bit rate carried on this transponder is 2 X 52.97 = ~106Mbps.

Line Mode	NS3	
Input Type	Bandwidth	?
Input Value [MHz/Msps/Mbps]	18	
Link Quality Type	CNR	?
Link Quality [dB]	10.79	
Carriers per Transponder	Multi	?
Roll-Off	5%	?
Frame Type	Normal	?
Pilots	Yes	?
Modulation	16APSK	
Code Rate	4/5	
Symbol-Rate [Msps]	17.1428571	
Occupied Bandwidth [MHz]	18	0.00%
Spectral Efficiency [Bits/Sec/Hz]	2.9433286	37.19%
Info-Rate [Mbps]	52.9799147	37.19%
CNR [dB]	10.79	
Esat/N0 [dB]	17.79	
OBO [dB]	7.00	

Non-Linear Degradation [dB]	0.00	
SNR (Es/N0) [dB]	11.00	
SNR threshold [dB]	10.91	
EbN0 [dB]	6.10	
Effective Code Rate	0.77	

MODCOD calculation for Symmetrical link

2.2 Symmetrical link case with NovelSat DUET

For this scenario, the total power per carrier must remain the same. In this case it is 37dBW.

Using NovelSat DUET makes it possible to utilize 36MHz for each earth station.

Note: If there were no power limitation, one could get double the data rate (106Mbps) for each side. But this would require 40dBW per carrier which is also double the power, and a total of 43dBW from the transponder, which, of course, cannot be achieved.

Therefore, the same 37dBW power must be divided between two earth stations.

However, the same 37dBW over 36MHz is now divided, thus, each symbol on the receive link (Es/No) only gets half the power (-3dB), yielding an SNR of 8dB (maintaining the same link margin), and CNR of 7.79dB.

Therefore, a lower MODCOD must be used, as follows:

16APSK 3/5 with Eb/No threshold of 4.36dB and threshold SNR of 8dB, but as can be seen from the calculations below, each earth station can receive 79.33MBps.

Given Link Quality		
Line Mode	NS3	
Input Type	Bandwidth	?
Input Value [MHz/Msps/Mbps]	36	
Link Quality Type	CNR	?
Link Quality [dB]	7.79	
Carriers per Transponder	Multi	?
Roll-Off	5%	?
Frame Type	Normal	?

Pilots	Yes	?
Modulation	16APSK	
Code Rate	3/5	
Symbol-Rate [Msps]	34.2857143	
Occupied Bandwidth [MHz]	36	0.00%
Spectral Efficiency [Bits/Sec/Hz]	2.20361523	36.61%
Info-Rate [Mbps]	79.3301485	36.61%
CNR [dB]	7.79	
Esat/N0 [dB]	14.79	
OBO [dB]	7.00	
Non-Linear Degradation [dB]	0.00	
SNR (Es/N0) [dB]	8.00	
SNR threshold [dB]	7.81	
EbN0 [dB]	4.36	
Effective Code Rate	0.58	

MODCOD calculation for Symmetrical link with duet

So, now the total transponder can have a data rate of: 2 X 79.33MBps = ~158.6Mbps.

A total improvement of 158.6/106 = 49% in capacity.

This is due to Shannon's law of channel capacity => C = BW * log (1 + P/N).

The power is reduced but it is in a logarithmic factor while the bandwidth is multiplied by 2 and is in a linear factor, so there is a gain.

3 Asymmetric links with NovelSat DUET

In the following scenarios, the same approach of dividing total power of the transponder between two earth stations applies. That is, maintaining the desired SNR at each earth station, while not violating the total transponder's power limitation.

3.1 Symmetric Data rate, Asymmetrical antenna diameters

This case utilizes a 9m antenna at the HUB site, and 3.8m antenna at the remote site.

The diameter difference yields an antenna gain difference of $20*LOG_{10}(\frac{9}{3.8}) \cong$ 7.5dB

Since this case uses a symmetrical data rate, it leads to the fact that both earth stations must maintain identical SNR and therefore identical MODCODs.

The only existing solution for this case is to divide the gain difference to compensate for the difference in antenna sizes in order to guarantee an identical SNR on both sites.

This leads to the following calculation:

The total transponder power remains 40dBW.

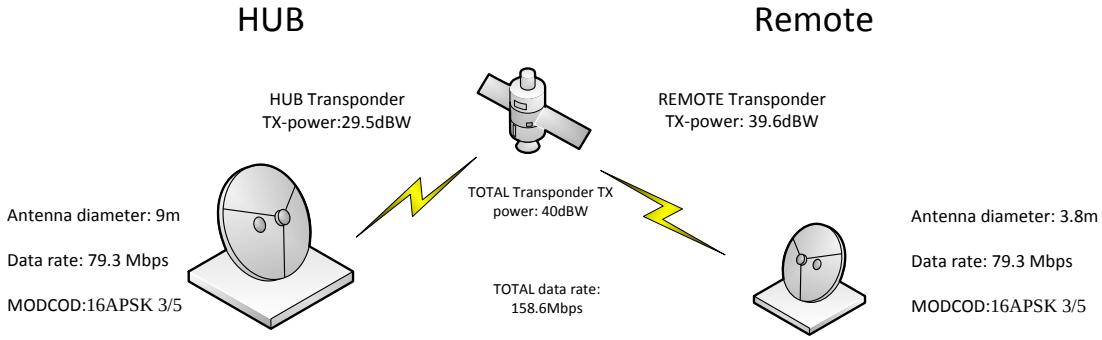
The transmitted transponder power toward the 9m antenna is: 37dBW – 7.5 dB = 29.5dBW.

This power reduction is possible since the 9m antenna will compensate for the power loss with its higher gain.

The remaining transponder power that will be transmitted to the 3.8m antenna site will be: 39.6dBW.

Note: 29.5dBW + 39.6dBW = 40dBW.

In this case, it is assumed that the same data rate as in 2.2 (158.6Mbps) is applied as is the same MODCOD (16APSK 3/5).



Symmetric Data rate, Asymmetrical antenna diameters

3.2 Asymmetric data rate, Symmetrical antenna diameters

For this scenario it is assumed that the data ratio between stations is 1:4 (in other words, the Hub site receives ~30mbps while the remote site receives ~120mbps).

Antenna sizes at both sites are identical, thus, no gain difference between antennas exists.

Since different data rates are needed, different MODCODs will be received at each of the sites.

The total bit rate is 157Mbps, as above.

The transmitted power of the transponder will be divided relative to the necessary bit rate.

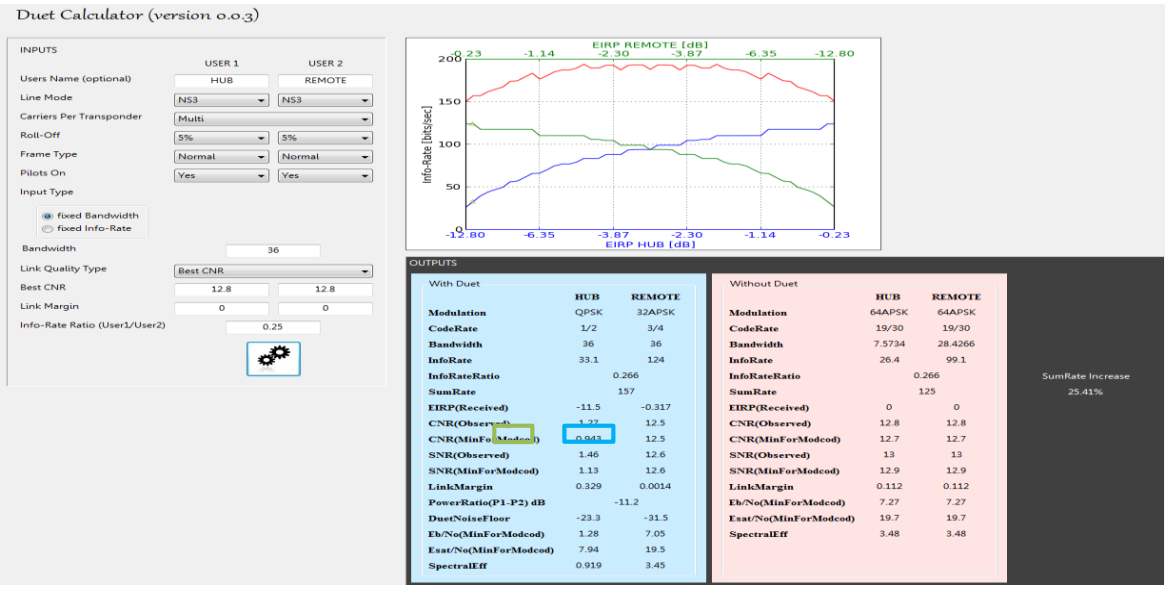
Using the NovelSat DUET calculator (below), you can see that in order to achieve a bit rate of 157Mbps, a CNR of 12.8dB, for example, is needed on both ends of the link.

An info rate ratio of 0.25 is given.

The required power from the transponder toward each of the sites is as follows:

HUB transponder power: (~30mbps) = 40dBW – 11.5dB = 28.5dBW

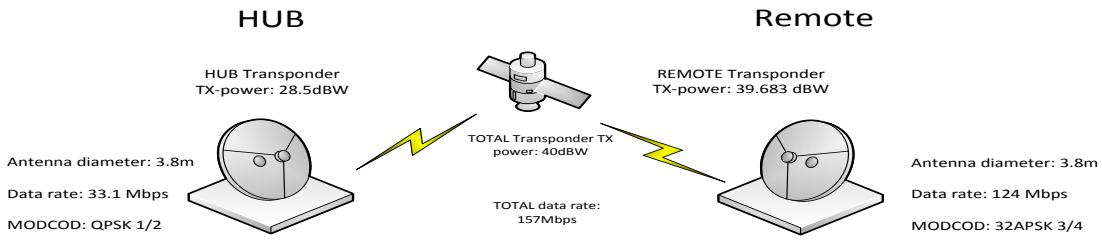
Remote transponder power: (~120mbps) = 40dBW – 0.317dB = 39.683dBW



NovelSat DUET calculator for asymmetric data rate, symmetrical antenna diameters

To make sure that the maximum transponder power is not violated it is calculated that:

28.5dBW + 39.683dBW = 40dBW



Asymmetric Data rate, Symmetrical antenna diameters

3.3 Asymmetric data rate, Asymmetrical antenna diameters

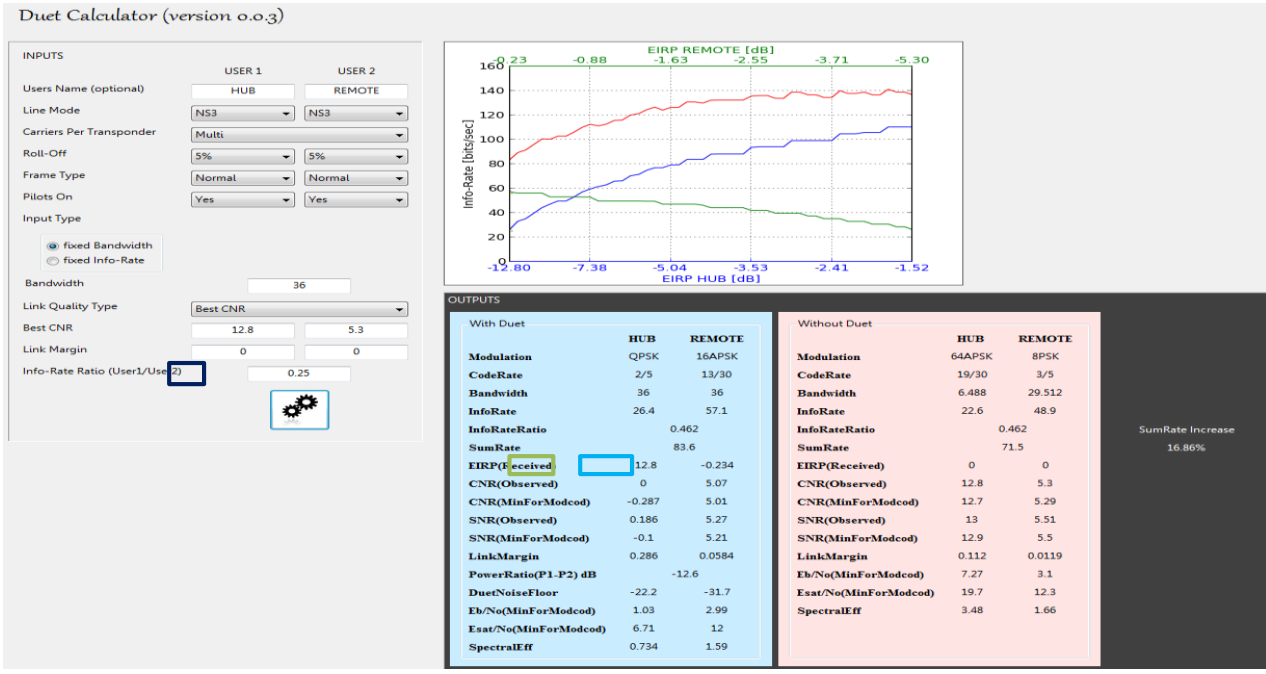
For this scenario it is assumed that the data ratio between stations is 1:4 and the antenna sizes at both sites are different, like before: 9m antenna for the HUB and 3.8m antenna for the remote.

Different data rates are needed, so different MODCODs will be received at each of the sites.

The diameter difference yields an antenna gain difference of $20*LOG_{10}(\frac{9}{3.8}) \cong$ 7.5dB

Using the NovelSat DUET calculator (below), it is seen that in order to achieve a bit rate of 157Mbps, a CNR of 12.8dB, for example, is needed on both ends of the link, but as there is a gain difference between the antennas we will recalculate the CNR for the smaller remote antenna (3.8m) as follows.

12.8dB – 7.5dB = 5.3dB.



NovelSat DUET calculator for asymmetric data rate, asymmetric antenna diameters

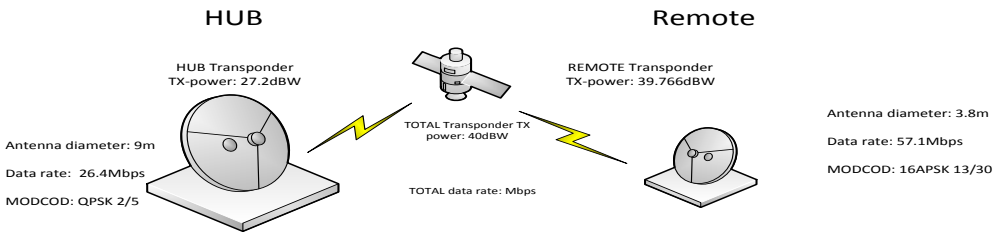
The required power from the transponder towards each of the sites is as follows:

HUB transponder power: (~30mbps) = 40dBW – 12.8dB = 27.2dBW

Remote transponder power: (~120mbps) = 40dBW – 0.234dB = 39.766dBW

An info rate ratio of 0.25 is given.

As seen above, it is not possible to achieve the required bit rate of 157Mbps but only 83.6Mbps at the given link conditions.



Asymmetric Data rate, Asymmetrical antenna diameters

4 Mathematics Appendix

When adding two logarithmic power variables, the following guidelines will need to be applied:

Ptotal = 10*LOG10(10^(P1/10)+10^(P2/10))

When calculating the gain difference caused by antenna diameter differences:

Gain difference = $20*LOG_{10}(\frac{D1}{D2})$

Shannon's law of channel capacity:

C = BW * log (1 + P/N).

5 About NovelSat

NovelSat is a technology company dedicated to providing the next-generation modulation standard for satellite communications. NovelSat NS3™ technology – encompassing ultra-high end modulators, demodulators, modems and ASICs – essentially replaces DVB-S2 as the industry standard. NovelSat delivers the fastest data rates, the widest pipe and the most compelling ROI. That means you get the best performance at the lowest costs, resulting in the highest profits.

5.1 Contact Information

Support Hot Line

Boston, MA: +1. 617.658.1419
Milan, Italy: +39.023.631.1980
Zurich, Switzerland: +41.435.081.067

Or via our support email at: support@novelsat.com

You can also contact us at: info@novelsat.com

NovelSat US

25 Tanglewood Rd.
Newton, MA 02459