White Paper

Datum Systems Smart Carrier

Next Generation Carrier Cancellation

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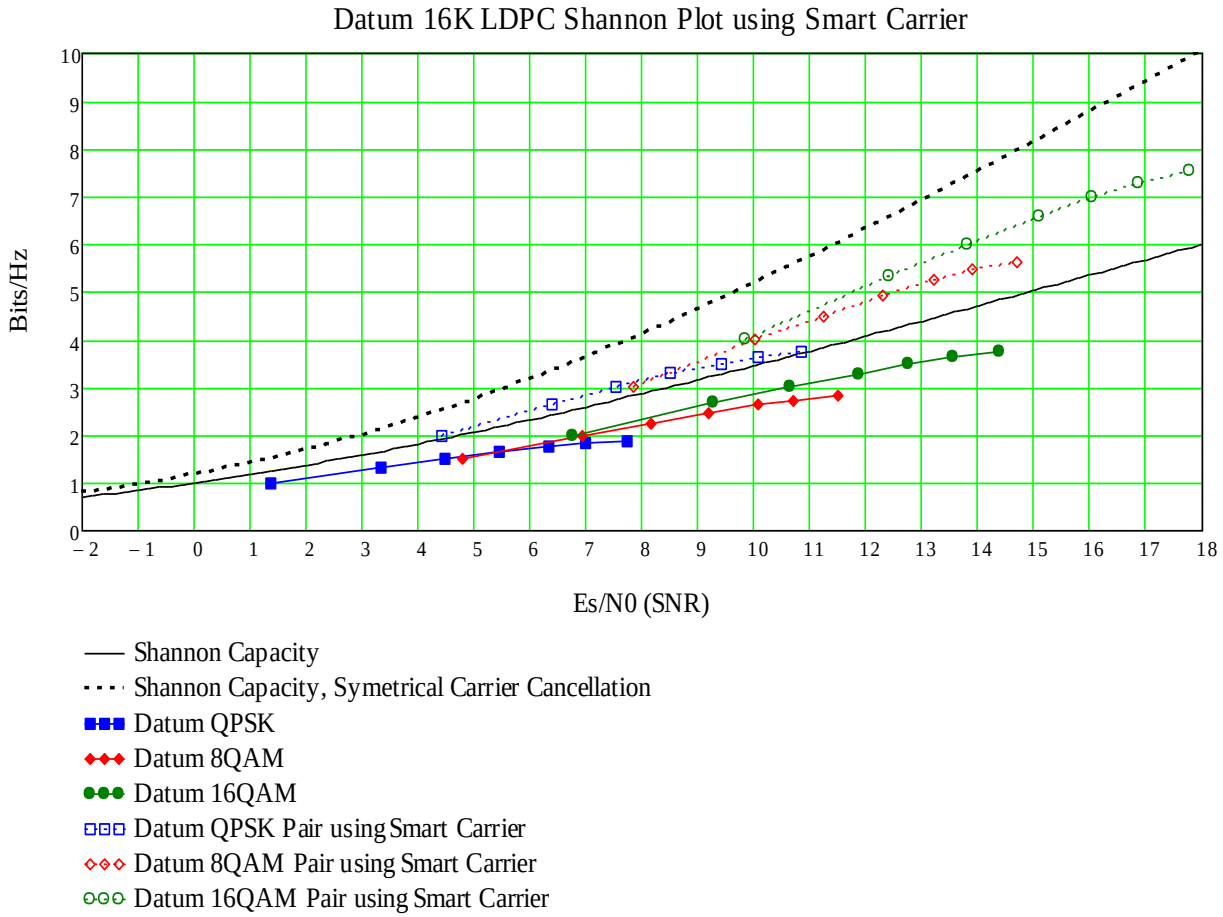
Introduction

This white paper explains how to use Datum's new "Smart Carrier " carrier canceller. Carrier cancellation is a technique where a duplex satellite link can have substantially higher capacity given that both earth stations can see the combined downlink. Smart Carrier can be used in the same manner as existing carrier cancellation technology, but the implementation is architecturally different and has advantages. It works at baseband instead of requiring the input IF signal to be sampled and digitized. This eliminates considerable hardware in a modem, allowing Datum to provide a very cost effective solution.

Symmetrical Carrier Cancellation

Carrier cancellation can dramatically increase the capacity of a satellite link. The Shannon Capacity of a satellite link is actually increased over that of a unidirectional link since the entropy of the link is cut in half for symmetrical cancellation. Smart Carrier does not "beat" Shannon but it takes advantage of the fact that the bound moves if cancellation is properly used.

This theoretical capacity increase is maximum for matched modulation coding combinations and matched symbol rates. The plot below shows Datum modulation/coding combinations for our M7 16K block size LDPC with and without Smart Carrier. This plot is for the matched case.



Asymmetrical Carrier Cancellation

The theoretical Shannon capacity increase only applies over the range where the two carriers overlap. If there is a symbol rate mismatch or carrier offset then capacity goes down. There is obviously a point where it does not pay to use cancellation.

The Datum Smart Carrier architecture has limits on the offsets. The present configuration requires that symbol rates be matched within 20%, and that the carrier frequency offset by within 5% of the lowest symbol rate.

Datum understands that sometimes data rates on a link are not symmetrical and antenna sizes differ on each end of a link. This forces a degree of asymmetry.

Fortunately there is a way to get good performance with these cases. The trick is to match the symbol rates as closely as possible. Datum has a substantial range of modulation/coding combinations. A list of recommended combinations is shown in the following table.

Datum Recommended Modulation/Coding Combinations								
Datum Mod Type	Code Rate		EbN0	Raw B/Hz	Bits/Hz	EsN0	Ratio Up	Ratio Dn
Mod Type 16QAM	16	17	8.63	4	3.76	14.39	3.53%	
Mod Type 16QAM	10	11	7.95	4	3.64	13.56	3.90%	-3.41%
Mod Type 16QAM	7	8	7.32	4	3.50	12.76	6.25%	-3.75%
Mod Type 16QAM	14	17	6.68	4	3.29	11.86	9.80%	-5.88%
Mod Type 16QAM	3	4	5.87	4	3.00	10.64	12.50%	-8.93%
Mod Type 16QAM	2	3	5.01	4	2.67	9.27	7.94%	-11.11%
Mod Type 8QAM	14	17	5.24	3	2.47	9.17	9.80%	-7.35%
Mod Type 8QAM	3	4	4.63	3	2.25	8.15	12.50%	-8.93%
Mod Type 8QAM	2	3	3.91	3	2.00	6.92	14.29%	-11.11%
Mod Type QPSK	7	8	3.9	2	1.75	6.33	6.25%	-12.50%
Mod Type QPSK	14	17	3.27	2	1.65	5.44	9.80%	-5.88%
Mod Type QPSK	3	4	2.72	2	1.50	4.48	12.50%	-8.93%
Mod Type QPSK	2	3	2.09	2	1.33	3.34	33.33%	-11.11%
Mod Type QPSK	1	2	1.38	2	1.00	1.38	50.00%	-25.00%
Mod Type BPSK	2	3	2.09	1	0.67	0.33	33.33%	-33.33%
Mod Type BPSK	1	2	1.38	1	0.50	-1.63		-25.00%

These combinations were selected based on Shannon efficiency. Some combinations require more power (Es/N0) to achieve a given bits/Hz and they are omitted from the graph. Note that 8PSK is also omitted since in every case Datum 8QAM outperforms it.

Note that over a bits/Hz range of 1.5 to 3.76, there is a good modulation/coding combination within 15% of a given bits/Hz requirement. This means that over an asymmetrical link there is a usable combination for asymmetrical data over any case where it makes sense to use carrier cancelling. This is a very important result. Smart Carrier is perfectly usable and the apparent restriction actually helps a customer improve the efficiency of the link at lower satellite cost.

Link Budgets

Datum is aware that computing link budgets for carrier cancellation is problematic as there are so many options it is sometimes difficult to figure out what makes sense to do. We can help! Datum is prepared to run link budgets given reasonable data on earth station parameters and desired satellite.

Conclusion

Smart Carrier from Datum is a practical and cost effective technique for dramatically increasing the efficiency of a duplex satellite link.