Technical specifications and theoretical limits

Quote Amsat:

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* Not stronger than the Beacon
* No FM mode
* Nomodulation exceeding max. 2700 Hz BW
* No digital FM modes like C4FM, DSTAR...
* No transmission below the Lower Beacon
* No transmission above the Upper Beacon
* Excessive signals might trigger LEILA warnings
* Full-Duplex operation is mandatory
* Remote operation over Internet is undesirable
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AMSAT QO-100 / P4A
NB Transponder Bandplan

Uplink		Downlink			
Start [MHz]	End [MHz]	Start [MHz]	End [MHz]	Available [MHz]	Comment
		10489,500	10489,505	0,005	Lower Beacon 10489,500 MHz, CW F1A, + guard band
2400,005	2400,040	10489,505	10489,540	0,035	CW only
2400,040	2400,080	10489,540	10489,580	0,040	digimodes (500 Hz max. BW)
2400,080	2400,150	10489,580	10489,650	0,070	digimodes (2700 Hz max. BW)
2400,150	2400,245	10489,650	10489,745	0,095	SSB only (2700 Hz max. BW)
		10489,745	10489,755	0,010	Middle Beacon 10489,750 MHz, 400 Bit/s BPSK + guard band
2400,255	2400,350	10489,755	10489,850	0,095	SSB only (2700 Hz max. BW)
2400,350	2400,495	10489,850	10489,995	0,145	mixed modes (2700 Hz max. BW) & special purpose
		10489,995	10490,000	0,005	Experimental Beacon 10490,000 MHz, CW and other modulations + guard Band

HS-Modem Implementation

There are two limit values to be observed, which are prescribed for operation above QO-100: the maximum bandwidth is 2.7kHz and the maximum signal must not exceed the beacon level. These two values result in a window for the maximum achievable transmission speed of digital data.

According to Shannon-Hartley's law, the bandwidth determines the maximum number of symbols per unit of time. Shannon does not initially define how many bits are packed into a symbol.

Since the symbol rate has this physical limit, in order to increase the transmission speed, we have to

increase the number of bits/symbol. There are many ways to do this. Using phase modulation, for example, you can change the phase more or less. Each phase position then corresponds to one bit. At this point the second QO-100 rule “no signal stronger than the beacon” kicks in. This rule specifies basically a maximum signal to noise ratio. Noise leads to the points in the constellation diagram being blown up into “clouds”.

If too many phase states are used, it will eventually become impossible for the receiver to reliably distinguish individual symbols as noise increases (Fig. 2a-2c).

Since practically no interference, but only Additive White Gaussian Noise (AWGN) influences the signal when transmitting via QO-100, the following formula applies to the maximum bit rate:

max. bit rate [bps] = B * log(1+S/N) / log(2),

with B=bandwidth and S/N=signal to noise ratio. We use a maximum permissible bandwidth of 2700 Hz and an S/N of 10, which corresponds to a signal which is +10 dB above noise. This results in a theoretically maximum achievable Bit rate of 9340 bps (bits per second). Of course, one could also expect a higher SNR, but in satellite operation we want to work with low power and stations with small parabolic dishes.

A detailed explanation of these relationships can be found there.